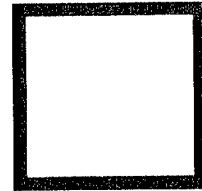


# AIR FORCE JOURNAL <sup>of</sup> LOGISTICS



SUMMER  
1982

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*"There is no single predictable future, rather there is a  
myriad of potential futures which we can influence and mold. As  
the future involves all of us, we all must share the responsibility  
for shaping it."*

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***Traditionally, a new decade brings plaintive predictions of the future and endless evaluations of the past. It is part of the journalist's constant search for copy.***

***As members of the defense community, we know full well the discussion of new policies, better strategies, and more complete doctrines to be useful, worthwhile, and important. We also know that without logistics, all are futile; but, then, that is our secret. That is the backbone of our challenge.***

***Your Journal has succumbed and consciously dedicates for the first time an entire issue to a theme. In this instance, the theme is "the future," a chronological device to take us well beyond the narrow confines of this decade. The idea for a theme was suggested to us by Mr. Oscar Goldfarb and he in turn did much to "beat the bushes" to help us get a fair and broad look at some of the concepts over our horizon.***

***To complement our presentation, we have asked for Mr. Goldfarb's words.***

***The Editor***

**"Our world is in a continuing state of change. A major contributor to this change is technology. To a great extent, logistics is a captive of technology especially as it is reflected in weapon systems and equipment.**

**It is quite a challenge to exploit technology to achieve an increasingly high level of weapon system performance and at the same time achieve a high level of reliability and supportability. It is also quite a challenge to exploit technology to achieve the needed level of performance within our logistics structure and still preserve the flexibility now provided by the human being. If we don't step up to these challenges, what are the alternatives?**

**The Air Force is stepping up to these challenges. We have a logistics R&D program which is becoming the model for all DOD. We have an active logistics long range planning program to provide the vision and direction for the future. We are just at the fringe of exploiting information technology which could profoundly affect the logistics structure and processes. These are beginnings and we still have a long way to go."**

**Oscar A. Goldfarb, Deputy for  
Supply and Maintenance, Office  
of the AF Deputy Asst Secretary**

# The Challenge for Logisticians—The Future

Lt Colonel Marvin L. Davis, USAF

Directorate of Logistics Plans and Programs

DCS/Logistics and Engineering

HQ USAF, Washington, D. C. 20330

It was November 1944, our air units were roving at will over Germany; General Hap Arnold, then Chief of the Army Air Forces, reflected:

... I had yet another job. That was to project myself into the future; to get the best brains available, have them use as a background the latest scientific developments in the air arms of the Germans and Japanese, the R.A.F., and determine what steps the United States should take to have the best Air Force in the world twenty years hence. There was no doubt in my mind but that a different pattern must be followed insofar as radar, atomics, sonics, electronics, jet planes, and rockets were concerned. This applied not only to airplanes, to the rockets used from ships and airplanes, but also to such types of projectiles as the big German V-2 rocket. When we added all such developments together, what did it mean for the future? What kind of Air Force must we have? What kind of equipment ought we to plan for twenty years, or thirty years hence? (1:532)

To pursue this objective, General Arnold recruited Dr. Theodore Von Karman to head a group of practical scientists and engineers. Their charter was to look into the future twenty years and determine what the Air Force would need. Their efforts were to be a guide to the Air Force commanders who would follow. The product of the Von Karman team was entitled *Toward New Horizons*; it has been credited with being the guiding document for USAF research and development during the 1950s.

Although the year is 1982 and the country is at peace, we logisticians also have yet another job. Our challenge is to address the ideas and capabilities needed to provide warfighting support at the turn of the century. We too must think ahead twenty years and then beyond. Our aim must be to consider the lessons of history and develop a vision for a logistics architecture in the year 2000.

## The Challenge

History has traditionally emphasized the operational dimensions of warfare—strategy and tactics. As Dr. Martin Van Creveld has pointed out in his book *Supplying War*, the logistical dimensions have been substantially ignored by most historians. (2:2) Logistics provides the "muscle" for an air force to deliver its warfighting potential. Without logistics, an airframe is nothing more than a hollow hulk—an uncocked rifle without bullets. When coupled with strategy and tactics, logistics enables the operational commander to create and sustain the strength of airpower.

All three elements of warfare must be well conceived, adequately provided for, and integrated if an armed force is to fulfill its objectives. As this country moves into the twenty-first century, its airpower will be measured, not only by the potential performance and quantity of its operational forces, but by the ability to deliver its destructive potential—where, when, and for

how long it is needed. Logistics fulfills this potential with the essence of power. As General Curtis LeMay said in 1956:

When I speak of strength, I am not speaking only of airplanes. I am speaking of airfields, fuel supplies, depots, stockpiles of aircraft parts, weapons and weapons stockpiles, control and communication centers, highly trained and skilled manpower—and airplanes. These constitute airpower.

In many cases, the logistics processes and infrastructure we possess today are outdated in terms of warfighting concepts and technology. The environment and operational requirements are changing and will continue to change. The battlefield of the future will be radically different from anything we have experienced to date.

To prepare for this environment, we logisticians must plan for the capabilities needed in the future. Then, we must work back from that point to program and budget the required resources to build a cohesive and integrated architecture like that graphically depicted in Figure 1. Our architectural framework for the future should drive the budget and not vice versa.

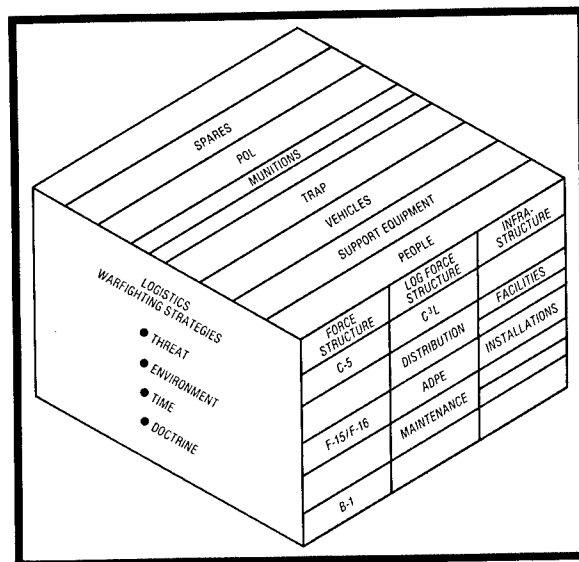


Figure 1.

## Logistics Long-Range Planning

The various attempts over the years to establish a long-range planning process in the Air Force are indicative of our tradition to be future-oriented. Since 1979, long-range planning has been a segment of the overall Air Force planning process. Logistics has been a vital part of this endeavor. (3:11) This process starts by inserting a long-range perspective into the early stages of the annual planning, programming, and budgeting

system (PPBS). The Secretary of the Air Force and the Chief of Staff accomplish this by providing a "top-down" focus in terms of objectives and priorities.

The process to provide this focus can best be described through the aviation analogy of an aircraft penetrating a line of thunderstorms to reach a distant airfield. Long-range planners are like a ground radar station scanning the horizon to locate thunderstorms (threats, obstacles, or limitations) and clear flying paths (opportunities). As planners, we transmit the information to those responsible for guiding the aircraft (senior Air Force leaders). These leaders, having available to them the alternative routes to reach a distant airfield, may then choose an appropriate path to reach the ultimate destination (national military objectives). But like the nature of thunderstorms, the obstacles may move or change their shape over time. Thus, the dynamic nature of our environment requires us to have a cyclical process. The nature of the environment may require an adjustment of the path along which the aircraft must travel. Depending on the amount of change, the final destination or objective may even need to be altered. (4:21)

In the interactive sessions of discussions about logistics held with the Secretary and the Chief, we attempt to provide assessments of key support issues facing the Air Force. Our aim is to present the implications for supporting air warfare at the turn of the century and to have our proposed objectives ratified. To enable all logisticians to formulate current decisions in consonance with these goals, we are documenting our future objectives and strategies in the *Air Force Logistics Long-Range Planning Guide*.

***"... logistical dimensions [warfare] have been substantially ignored by most historians."***

### **The Future Battlefield**

The future will require logistics support across a very broad spectrum of potential conflict. Combat could likely range from low level contingencies to theater conflicts to global warfare. This global strategy requires that air forces be capable of fighting at any level of conflict and inherently be able to move rapidly across the continuum of conflict. In order for logistics to sustain forces across this continuum, the logistics architecture of the future must be compatible with its environment.

The need to survive on the battlefield will be of paramount concern. The quest for survival will motivate the organizational structure, tactics, and logistics doctrine in the year 2000. The logistics infrastructure will not only be a direct target, but it faces potentially extensive collateral damage. Advanced nuclear, biological, chemical, and conventionally oriented weapon systems will make support operations extremely vulnerable and difficult to sustain.

Unaccustomed to being a major target on the battlefield, logisticians must recognize and deal with the fact that our equipment, facilities, and weapon systems will be primary targets and highly vulnerable to enemy attacks. We must expect our lines of support to be significantly damaged, C3 capabilities to be severely degraded, and the battlefield environment to be extremely hazardous due to multiple weapon threats.

***"... the dynamic nature of our environment requires us to have a cyclical process."***

Our challenge is to devise the concepts and processes that will enable the support infrastructure to survive and sustain operations. Particularly if conflict should escalate to global warfare, the potential requirement for credible warfighting capabilities poses a herculean challenge to logistics. Whether it be global or theater warfare, or even a combination of both, the support infrastructure may face revolutionary change.

In a similar fashion, the inherent flexibility and maneuverability of air forces will also take on new dimensions in the twenty-first century. With the surveillance and firepower capabilities of our potential adversaries, concentrations of weapon systems or support itself will be vulnerable. Air forces will need to move frequently on the battlefield. To complement this requirement, support capabilities will have to be highly tailored as well as mobile and survivable. If our forces are to be truly mobile, support requirements must be substantially reduced. Whether it be in Europe or in austere locations with little to no infrastructure, support requirements must be reduced for U.S. forces, not only to respond rapidly, but to redeploy frequently to survive.

The lack of time will also be a critical factor. Support systems, procedures, and people must be prepared to rapidly engage in wartime operations. The environment of the twenty-first century will not permit a major transition from a peacetime to a wartime posture. Thus, in the future peacetime environment, the support structure and its people must be organized, equipped, and trained in their wartime posture. We logisticians need to change our perspective—we must organize for war and conduct peacetime operations from within that framework. It is our job to enable our forces to be sufficiently mobile and flexible so that the National Command Authorities have the ability to respond with air forces across the full spectrum of conflict. The "muscle" of logistics is a vital ingredient in, not only providing responsive forces, but also enabling the combat commander to employ and sustain the military initiative.

To do this, the logistics force structure—those structural elements of logistics which translate airframes and consumable resources into decisive destructive power—must be focused on the end product of combat sorties. The logistics computers, telecommunications, process control systems, maintenance processes, and our distribution capabilities must be developed to perform essential wartime operations. Within this posture, peacetime operations should be efficient and streamlined as possible, but not at the expense of potential combat effectiveness. Our day-to-day perspective must emphasize warfighting; management efficiency should be a secondary goal. We need to recognize the lessons of history: warfare—if one is to be effective—is inherently inefficient; it has to be in order to appreciably increase the probability of success. Peacetime requirements and processes must not degrade our warfighting capabilities.

## What Do We Focus On?

It is obvious that our future environment poses many challenges. The trends suggest that advanced technology will continue as an important ingredient in contributing to improved weapon system performance. But this same factor has been the force behind support requirements, and these have been growing substantially. To counter this problem, some defense analysts have suggested that we should design simpler systems if we are to maintain aircraft at high sortie rates, particularly in austere environments.

However, if advanced technology is needed to provide increased performance, then a major corollary, technology thrust is required to reduce support actions. What we need is a balance between performance and support to achieve optimum combat capability. Neither performance nor supportability is an end in itself. We must achieve the appropriate proportion between the super performance aircraft for which one sortie a day is possible and the degraded performance aircraft for which six sorties are possible. The critical factor is the future warfighting environment in which we will find ourselves. Not only will increased performance be necessary, but the essence of support itself will need to change in response to the makeup of the support force and the threats of the battlefield. Reliable and supportable systems must become as critical as the technical performance they produce on the battlefield.

The new technology thrusts must reduce both the type and quantity of support actions needed at the geographical point where sortie generation occurs. For example, the twenty-first century may likely see a reduced manpower pool, both in terms of numbers and innate abilities to maintain complex systems. If a sophisticated weapon system is needed to handle the threat, then the technology of that system must be transparent to make it easier to replace or fix when it fails. If that sophisticated system technology can be designed to represent less complexity to the maintenance technician, we then reduce the difficulties in turning aircraft for combat sorties.

But since failure will inevitably occur, proficiency training should also be conducted with degraded systems. Aircrews and support crews alike should train in a Red Flag environment with the limited capabilities that will invariably exist in combat, particularly when high sortie rates are required in austere, dispersed locations.

Although the need for more reliable weapon systems is not a new idea, our approach to achieve this goal must be. We logisticians must improve the means by which we quantify the meaning of supportability in ways that make sense to an aircraft design engineer. These designers have amassed a great wealth of experience in dealing with the "calculus" relating performance to design. But experience in relating design to supportability is much more sketchy and vague. We must develop the means to articulate logistics supportability in terms meaningful to the design engineer, comparable to the performance criteria of energy maneuverability and turn radius. These terms have precise meaning to an engineer; meantime between maintenance actions, maintenance hours per flying hour, and mission capable rates are considerably less precise. In other words, we must do a better job of defining our maintenance environment of the future to the engineer.

***"... we must organize for war and conduct peacetime operations ...."***

As we create the quantitative design expressions of what supportability is, we must also develop the incentives and processes by which aerospace companies produce more reliable aircraft and subsystems. The name of the game today is still performance. For the future, the Air Force must send some clear signals to industry that both performance and logistics are operational requirements. Without these signals, industry will not make the internal changes to treat supportability and performance as comparable design characteristics. For example, we should require our contractors to develop a range of aircraft or weapon system designs which would represent trade-offs between performance and "supportability." These trade-off designs would be presented during Milestone 0 acquisition activities to enable senior Air Force leaders to select the design option that will be suitable for our future operational environment. In this endeavor, systems would be designed to be highly reliable and supportable, not only to sustain operations in future combat locations, but also to reduce the need to deploy large amounts of complex, highly vulnerable support equipment.

The second focus of our future planning should be on survival. No longer will the fixed base be a sanctuary; no longer will we be able to link our forces inherently to fixed installations. Forces and their associated support will have to disperse to survive and sustain operations. Thus, the premium will be placed on small, decentralized, self-sufficient support units to sustain combat. Just as the signature of aircraft must be reduced for aerial combat, small, highly capable support units with a reduced signature will also have enhanced utility. As depicted in Figure 2, dispersed operations will favor aircraft and support systems able to operate from a range of locations to include semi-improved areas to roads to short strips of damaged runways.



**Figure 2.**

The dispersal of critical assets—both weapon systems and their support—will be a key tactic in the year 2000. Dispersal will conceal or reduce the signature of assets on the ground much the same way that stealth technology may mask the presence of aircraft in the air. Likewise, responsive and mobile support will be as

critical to the mission as are the aircraft they support. In organizing for war, the need to survive may also dictate that we place more and more of our forces on alert. Warning times may be minimal in the twenty-first century, and our support structure must be ready. Our thinking may need to evolve to the point where we treat aircraft like ICBMs; e.g., weapon systems would be on alert and that condition would be degraded in order to perform essential training and maintenance.

***"...logisticians must improve the means by which we quantify the meaning of supportability..."***

To sustain the kind of dispersed combat operations that I have portrayed, the concept of self-sufficient weapon systems will also be necessary. To complement the technology thrust of reliability, weapon systems must be designed for integral support. This concept will enable small numbers of master mechanics, equipped in a mobile configuration, to turn aircraft rapidly for high sortie generation rates at austere locations.

Additionally, this dispersed operational concept will obviously warrant new distribution concepts and capabilities. For example, some amount of dedicated in-theater airlift and highly mobile ground transportation will be necessary to sustain dispersed operations. The costs may be high but are realistic where they are placed in perspective relative to enhanced warfighting effectiveness.

### How Do We Get There?

Change is difficult to bring about in any large institution. But the demands of our new weapon systems and the needed changes in our logistics force structure underscore the importance of our everyday actions being forward-looking. Using the focus of our logistics long-range planning, we need to orient our actions to build a logistics architecture suitable to future operational requirements. An essential element of the planning activities depicted in Figure 3 is a logistics research and studies program. Our intention is to express logistics requirements in terms meaningful to Air Force research and study agencies as well as to industry for their independent research and development (IR&D) efforts. For example, the Air Force Systems Command laboratories are using the logistics long-range planning objectives to develop thrust areas aimed at solving problems of reliability, maintainability, and support. By combining specific logistics research requirements with ongoing activities, the laboratories are working to solve long-term logistics problems.

***"...we need to orient our actions to build a logistics architecture suitable to future operational requirements."***

One of these laboratory thrust areas concentrates on a design for logistics. The basis of the work spawns from the recognition that some 85% of the life-cycle cost decisions for a major weapon system are locked in before full-scale development. Conversely, the actual expenditures are small with roughly 90% of the life-cycle cost incurred after the production milestone. The leverage achieved through up-front expenditures to make design more reliable and compatible with its operational environment becomes very apparent. We are moving forward in the areas of integrated logistics design, structural design criteria, and diagnostic technology in an attempt to reduce the manpower and associated logistics burden.

As we strengthen the logistics R&D program, we continue to concentrate on research which will result in long-term improvements. To deal effectively with the dynamics of our future environment, we are specifically funding for logistics concept development, design trade-off, and weapon system demonstrations. The potential for R&D to help us solve our problems is tremendous.

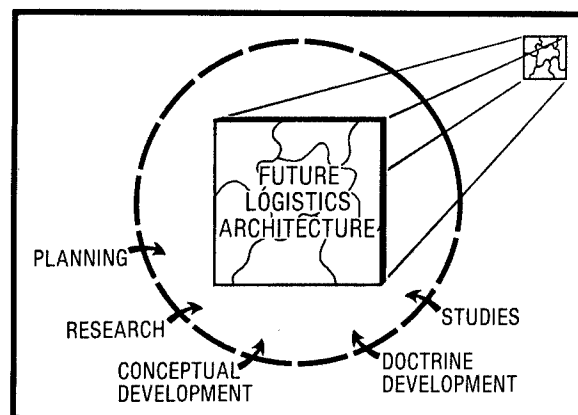


Figure 3.

### When Do We Start?

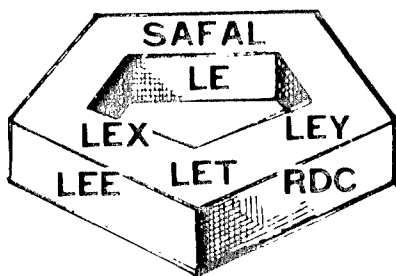
The operational environment of the twenty-first century presents us with demanding challenges. We cannot afford to ignore the challenges nor leave them to others. We must start now. The future requires all of us to dedicate a portion of our time. Our long-range planning process provides us the mechanism to examine the future environment and to plan for it. The future starts today—every decision we make today affects that future. The challenge is there—the real question is whether or not we are up to the challenge.

\*\*\*\*\*

"Any air force that does not keep its vision far into the future can only delude the nation into a false sense of security."  
General "Hap" Arnold

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# USAF LOGISTICS POLICY INSIGHT

## **CHECKMATE To Study Soviet Logistics**

Recent emphasis upon the United States Air Force's maintainability and sustainability has prompted Air Force Logistics CHECKMATE to analyze Soviet air logistics. The analysis examines the Soviet organization and reviews their capabilities to perform five prime logistics functions (aircraft maintenance, supply, POL, munitions, and transportation). Even though segments of the Soviet system have been well analyzed and documented, to our knowledge, no one has evaluated the system as a whole. This analysis of Soviet logistics capabilities provides planners a tremendous quantity of detailed data on the Soviet system.

## **New Bare Base Allowances Readied**

Allowances for Harvest Eagle (TA156), Harvest Bare (TA158), and the Tactical Fuels System Equipment (TA929, Part K) are being consolidated into TA157. This new TA will provide a comprehensive allowance source for mobile bare base equipment and serve as a guide for determining bare base requirements for both hardwall and softwall facilities. Allowances will be based on the number of personnel and the quantity/type of aircraft assigned to the bare base. TA157 is scheduled for publication 1 Jul 82. Allowances for vehicles required to support bare base operations will be established in a separate part of TA010, the current allowance source for vehicles.

## **Logistics Long-Range Planning Team Established**

The Deputy Chief of Staff/Logistics and Engineering and the MAJCOM/Deputy Chiefs of Staff for Logistics have established a Logistics Long-Range Planning (LRP) Team. The LRP Team supports a Chief of Staff initiative to enhance the dimension of the planning, programming, and budgeting process. The Team will be built around a cadre of Air Staff and MAJCOM people oriented toward future logistics planning. Their aim will be to improve the planning throughout the logistics community and to develop a clear vision for Air Force logistics in the year 2000. The Team members will also focus on near- and mid-term planning to ensure that evolving logistics programs are in consonance with Air Force long-range goals.

## **LOGMARS Implemented**

On 9 October 1980, OSD established the 3-of-9 bar code as the DOD standard symbology. OSD memorandum, 16 Feb 1982, directed all DOD components to proceed with implementation. The official program title is DOD "Logistics Applications of Automated Marking and Reading Symbols (LOGMARS)." LOGMARS bar code technology offers a key to unlocking financial benefits necessary to improving productivity within logistics functions and systems. PMD No. L-X 2068(1), 15 Mar 1982, designates HQ AFLC as the PMO responsible for development, initial acquisition, and implementation within the

Air Force. MAJCOMs and SOAs are responsible for individual follow-on replacements or upgrade programs to include budgeting and funding after initial acceptance. PMO will phase out as the technology becomes fully operational within the Air Force. Initial implementation is planned in wholesale receiving and base service store operations.

#### **Readiness of Reserve Logistics Units Examined**

The Logistics Management Institute is under contract to conduct a study for the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics. The study entitled, "Readiness of Reserve Logistics Units," examines the dependence of the total force on logistics assets from the reserve components of all services. The scope of the study will include: identifying the wartime logistics support functions supplied by reserve components and the planned phasing after mobilization for that support; identifying the types of reserve component logistics units affected by force modernizations; and assessing the adequacy of existing readiness indicators for reserve component logistics units. The focus of the Air Force phase of the study is to determine what supply, maintenance, and transportation functions will be performed by reserve components during war. The study is scheduled to be completed on 30 September 1982.

#### **Facility Energy Work Funded**

The Administration's amended FY82 budget included, for the first time, funds for facility energy work in the O&M arena. The Air Force has distributed \$27.9M to MAJCOMs in various O&M accounts for energy-related minor construction, metering, and building energy surveys. FY83 and succeeding year utility budgets have been reduced to reflect anticipated reductions expected from use of these funds. The funding fills a need which bases and MAJCOMs have had to fill from other programs for the past several years. The Energy Group at the Air Force Engineering and Services Center is the OPR for this program.

#### **Integrated Diagnostics Urged**

In April 1981, the Air Staff issued as policy a concept called Integrated Diagnostics, which requires acquisition managers to incorporate in the systems they acquire, a capability to detect and isolate 100% of the faults known or expected to occur in the prime equipment and the associated support and training equipment. This concept also delineates a program strategy for use to achieve this objective and already appears in some PMDs. The Air Staff has now chartered an Ad Hoc committee to outline the actions necessary to institutionalize this policy; the processing of changes and additions to existing directives should be underway in the near future.

#### **Clothing Support Point Set Up**

The Deputy Assistant Secretary of Defense (SM&T) has approved the establishment of a Specialized Support Point (SSP) for clothing. The SSP will be an additive AFLC mission located at Kelly AFB, Texas. Under this concept, the DLA depot at Memphis, Tennessee, will transfer management of that portion of Air Force uniform items required to support the Lackland Recruit Induction Center and military clothing sales stores within a 35-mile radius to the Air Force. Significant DOD savings are expected in the planned reduction of retail level inventory and the elimination of second destination transportation charges. A target date of May 1983 has been established for operation.

#### **Standard MLV Selected**

The Air Staff has designated the AN/ASM-607 Memory Loader Verifier (MLV) as the standard MLV for all systems having near-term requirements and using core memories, and has initiated actions through AFLC and AFSC to implement this standard. (MLVs are devices which load software into embedded computers at the organizational level of maintenance.) This action is based on the acceptance the AN/ASM-607 has received from acquisition agencies and users, and is the first step in an initiative which will provide a family of standard MLVs to meet all Air Force requirements. Agencies requiring MLVs should advise ASD/AXT, AFLC/LOWCT, or HQ USAF/LEYYS before initiating independent acquisitions.

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# Computer Graphics In Logistics Management

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---

## Abstract

*This paper is intended to serve as a point of departure for exploration of concepts and capabilities in computer graphics and to investigate the applicability of such systems to Air Force logistics management.*

*The discussion begins with a brief consideration of the role of management as it relates to information absorption and processing. The second section provides a description of a number of corporate and government applications which may provide germinal ideas for possible Air Force employments. The third section provides a brief review of the technology which is now available and the direction in which it is evolving. The last two sections provide, respectively, a measured and feasible menu of Air Force applications and a discussion of a few considerations necessary regarding cost-effectiveness.*

## Role of Management

To begin, we must ask: What role of management are we addressing in this effort to assess the relevance of computer graphics to Air Force logistics management tasks? The answer is that we are attempting to find ways to help supervisors, managers, and executives absorb and synthesize information for logical and accurate decisions. This mechanism of absorption and synthesis of information employs both the analytical and the intuitive capabilities of the manager. The process requires assimilation of great volumes of data and visualization of patterns and projections of that data in a search for trends, coherence, exceptional behavior, and correlations. How does the manager receive the data through which he begins this mental search for meaning? Mintzberg, in conducting a study of managerial performance, concluded:

I was struck during my study by the fact that the executives I was observing . . . are fundamentally indistinguishable from their counterparts of a hundred years ago. . . . The information they need differs, but they seek it the same way, by word of mouth. (15:122)

Certainly, this is a familiar process to those involved in almost any phase of Air Force management. Information is first extracted from a data base; next there is a subordinate attempt to organize the data into some coherent pattern, usually by plotting it on a view-graph. Finally, this subordinate verbally presents the data to the manager. Frequently, this verbal presentation becomes an iterative process wherein the manager reviews the presentation and suggests new angles from which to view the data, or perhaps requests inclusion of more or different data. In a sense, the subordinate in this process becomes a middleman between the manager and the data base.

It is possible that this relationship may be changing, at least in the corporate world. Many managers are now seeking information not by word of mouth but rather through pictures (computer graphics). Computer graphics systems may allow a machine to do much of the aggregation, synthesis, and presentation of data

which was previously performed manually. The fundamental importance of the form of this data presentation is emphasized by Herbert Simon, a prominent thinker in the field of information processing. Simon is quoted by Anders Vinberg as follows:

That representation makes a difference is a long-familiar point. . . . All mathematical derivation can be viewed simply as a change of representation, making evident what was previously true but obscure. (16:61)

Graphs are, of course, nothing more than a form of representation of data which makes the obscure comprehensible. Air Force managers have relied for many years upon graphically presented information, but this information is generated slowly and at great cost. The corporate world has been faced with like problems. In fact, according to Vinberg, the typical large corporation may require several hundred graphs to describe its operations. (16:61) Vinberg further suggests that these graphics may be generated as many as 26 times per year, requiring some part of the planning staff to spend as much as half of its time preparing such presentations. Under these circumstances, the data may be obsolete when it is presented; and clearly the complexity and sophistication of the displays must be limited.

Some of these problems of information overload, perishable data, and cost of production of presentations may be mitigated by the current technology of computer graphics. According to Takeuchi and Schmidt, the two most basic benefits of computer graphics are in saving the manager's time and in helping managers make better decisions. (15:123) Computer graphics save the manager's time by simplifying the interpretation of data and facilitating the communication of complex findings. Computer graphics help managers make better decisions by allowing them to: (1) scan and digest more information, (2) detect trends or deviations more readily, and (3) rapidly generate many different presentations.

The primary beneficiaries of this new technology are clearly the supervisory and management personnel. Management, however, incurs additional responsibility along with this capability. In the future, management may routinely be expected to have reviewed and evaluated many contingencies and combinations and presentations of data, simply because the capability to do so is becoming increasingly common. To the extent that this capability is used judiciously, it may improve the effectiveness and thus the productivity of our organizations. This kind of improvement seems especially important in light of some recent studies which have suggested that management may be part of the bottleneck in productivity growth. (15:130)

The author thanks 1Lt Karen M. Daniels, USAF, for her assistance.

The evidence suggests that private industry is knowledgeable of this possibility, at least to the extent that we may take administrative productivity as a surrogate for management productivity. Consider, for example, the attention which has recently been given to automation of office and administrative processes. As an index of the intensity of this effort, one might take the capitalization level of office and administrative workers, expressed as the capital-to-worker ratio. According to James H. Bair, that ratio was about \$2000 per person for office workers in 1978. (2:12) In that same year manufacturing workers were capitalized at about \$25,000 per person. According to the same source, the 1980 ratio for office workers was expected to be about \$10,000 per person; a fivefold increase in a period of only two years. Such a level of investment suggests that corporate managers believe that administrative productivity can be improved and that it is important to do so. Certainly, computer graphics would be among the systems employed to automate work which was previously slow and manpower-intensive.

### Some Examples of Current Use

The corporate world in the past few years seems to have been moving rapidly toward increased use of computer graphics in management, engineering, and design implementations. Although there is some evidence that government and military organizations are also embracing this new technology, they appear to be considerably slower in their implementation than private industry. If it is true that the widespread acceptance of this capability in private industry implies that such systems contribute positively to productivity and profits, then it is important that government and military organizations carefully assess operations to determine whether they are missing an opportunity for productivity enhancement.

In the following paragraphs, we will discuss a number of specific applications by private industry and one employment by a US Army project management office. The purpose in reviewing these cases is to generate thought in the Air Force logistics community as to what, if any, current applications should be considered in the Air Force logistics system.

For convenience, we have separated these applications into two groups. The first, computer assisted design/computer assisted manufacturing (CAD/CAM), will be illustrated by two brief examples. The second category, management information, includes a wide variety of applications; and we will discuss a number of these in an effort to stimulate thought in this more abstract area.

In the first group, the field of computer assisted design, General Motors and McDonnell-Douglas, to mention only two, have been active for more than a decade. (15:123) In each of these applications, computers store and present three-dimensional prototypes of products which are in the design stage. Engineers make proposed changes to the design directly on the screen and then immediately observe and analyze the ramifications of these changes through algorithms which are a part of the system software.

At General Motors, clay models of a proposed car design are digitized and then read into computer memory. Designers may make tentative alterations in the design by using a light pen directly on the screen or

by typing in specifications of the change. The computer immediately calculates the effects of such a proposed change on the car's performance in terms of weight, stability, and other factors. In a similar application, GM has developed a computer graphics-assisted technique for analysis of combustion chamber design and performance. Figure 1 shows the model of a combustion chamber, and Figure 2 shows the associated graphics output of combustion chamber performance taken directly from the GM graphics equipment.

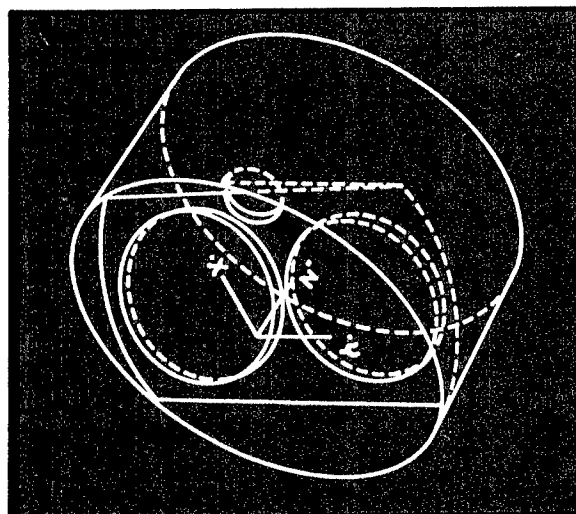


Figure 1: Model of Combustion Chamber. Reprinted with permission © 1981 Society of Automotive Engineers, Inc.

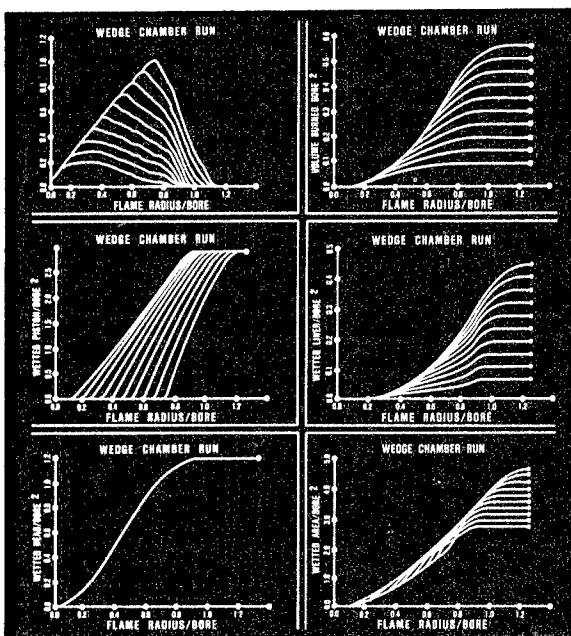


Figure 2: Graphics of Combustion Chamber Performance. Reprinted with permission © 1981 Society of Automotive Engineers, Inc.

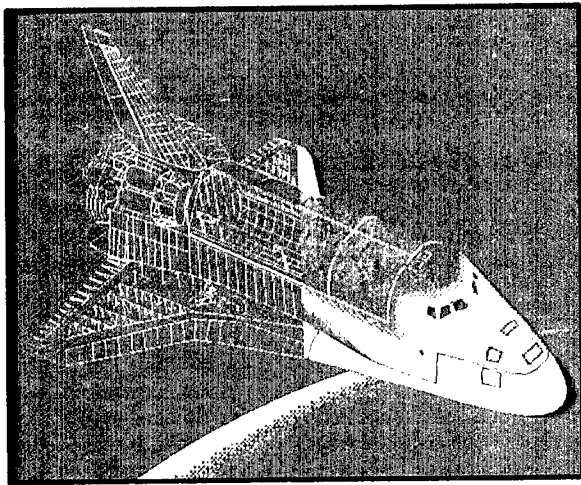
McDonnell-Douglas, in another CAD/CAM application, has used computer graphics to assist in design work on the F-18 aircraft. Again, the basic

design of the prototype is digitized and read into the memory of the computer. With the basic aircraft design displayed on the screen, engineers introduce proposed modifications and then observe the predicted changes in aircraft performance. Figure 3 is an example of graphics used in aerospace design work.

Although the relevance of the above applications to base-level logistics management tasks is not obvious, there may be analogues in hardware-oriented work, such as troubleshooting of aircraft systems, fault isolation, and testing of proposed corrective actions.

The second group of computer graphics applications, in the field of management information, has been divided into two categories. The first category includes geographic or geometric information which typically requires the depiction of a map or other symbolic representation of an area of interest. Figure 4 contains an example of a computer-generated map. The second category incorporates that whole range of abstract presentations of numerical information, including two and three dimensional presentations on Cartesian coordinates, bar charts, pie charts, Gantt charts, network models, and other methods of depiction limited only by the imagination.

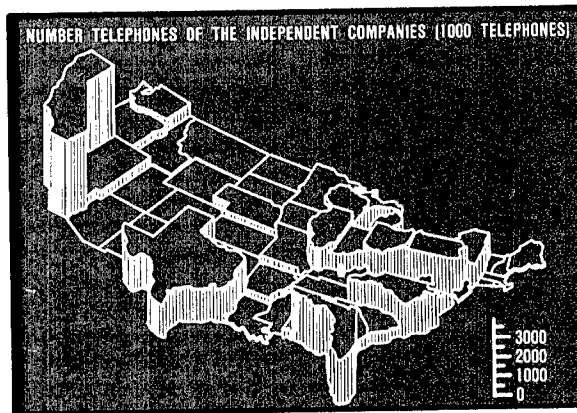
In the category of geographic implementations, an excellent example of a rather extensive application is found in the work of Business Industry Display, Inc., of San Diego. (16:63) This company publishes *World Energy Industry* which is a nation-by-nation summary of production and consumption of energy.



**Figure 3: Graphic Representation of Space Shuttle. Created using Hewlett-Packard 9845C Graphics System.**

Their publication includes a full page of data and a page containing four-color graphs for each country. In all, the report includes 130 color pages with more than 500 charts and graphs. The negatives for these charts are produced by computer graphics and reproduced on computer output microfilm (COM) in less than two hours. To produce this same product using conventional techniques would have required about *one day per page*.

General Motors has also been very active in applications of computer graphics to the management of administrative information. In the field of marketing, GM uses massive amounts of data. In fact, one marketing manager commented that he was swamped by literally truckloads of data products before he turned



**Figure 4: Three-Dimensional Maps. Produced by ODYSSEY Software System at Harvard Laboratory for Computer Graphics and Spatial Analysis.**

to computer graphics to relieve the information burden. (15:124) In one of the most frequently used marketing applications, GM uses computer graphics in its site location studies. For example, in order to study Cadillac dealer locations, GM computer graphics systems plot a color-coded map of an area which shows concentrations of Cadillacs (or competitive vehicles) registered in that area. Overlaid on this plot in a different color are the existing dealerships. In viewing this display, it is easy to see areas of relatively heavy concentration of high-priced vehicles which are not serviced by a Cadillac dealership. To digest such information from printouts would be a very time-consuming process. To generate manual graphics showing the same information similarly would be a time-consuming and expensive process, and would not be likely to provide up-to-date data.

The Taubman Company, a developer of regional shopping malls, has installed a computer graphics system which greatly simplifies its review of shopping mall productivity. As the number of tenants per mall in Taubman Properties increased from about 30 or 40 in the 1960s to 200 in the 1970s, the problem of productivity analysis of mall floor space became increasingly burdensome for Taubman executives. Drawing rational conclusions from review of the many sales reports became increasingly difficult. The company instituted a computer graphics capability which shows a simplified view of floor space in a given mall. Each section of the floor space is color coded according to its productivity index (retail sales per square foot of selling space), with black showing the highest productivity and lighter colors showing lower productivity areas. According to management, this capability has greatly simplified their task of analysis and review of retail productivity. Taubman's vice president for marketing believes the system will lead to better management of existing operations and better planning for future tenant space allocation. (15:126)

We now turn our attention to the second category of applications under the heading of management information, the set which includes all of the abstract, non-geographic depictions. Let us first consider Gould, Inc., a Chicago-based company with annual sales of about \$1.3 billion. This company recently installed a system designed to assist its top decision makers. The system takes various performance indicators, such as inventories and receivables, directly from the

information in the corporate data base and displays them on graphics terminals. Individual terminals were installed in the offices of managers both at headquarters and in field offices. A manager is required only to type in a three-letter keyword to call up a display of interest, such as sales figures, balance sheet, inventory, etc. There are 75 such displays available on the system. The system automatically flags significant deviations from planned performance figures and ultimately is intended to provide managers with the capability to input what-if questions and then review the effects on the output displays. In 1976 Gould executives, operating a company with annual sales of \$891 million, had available instantaneous summaries of sales, backlogs, receivables, and payables either on screens in their offices or on a large screen in the board room. Eight years earlier, before implementation of computer graphics, with sales of \$115 million, executives had only monthly summaries of this same information on which to base decisions. (9:16)

In a similar application, D. W. Phillips International employs computer graphics to assist in management of 24 subsidiaries with over 1400 retail outlets in 17 countries. Although the company had sales in 1976 of \$24 million, and was posting an annual growth rate of 25%, it still operated with only one general management official per country. The company has instituted an interactive computer graphics system which will allow managers to grasp problems at a glance and work directly with the computer by using a light pen. Management is intent on continuing the firm's international growth with increasing profit margins by reducing management overhead through improved management effectiveness; clearly this is a company which believes that computer graphics is a positive factor in management productivity. (9:20)

Esmark, Inc., has implemented a computer graphics capability with three graphics terminals tied to an HP1000 minicomputer. This system is the heart of their corporate strategy center, a sort of electronic board room. Executives are said to be able to learn the system in less than five minutes; inputs are typed on a simplified 12-key keypad instead of the usual typewriter style keyboard. The equipment allows executives to reduce information to simple forms for analysis of Esmark stock performance, for evaluation of potential mergers and acquisitions, and for numerous other analyses. (17:26) Figures 5 and 6 are examples of graphics products which are available through the Esmark Corporate Strategy Center.

The United States Army Patriot Program Management Office has demonstrated a unique employment of interactive computer graphics. This program office has loaded a network model of its program plan into an interactive computer graphics system. The level of resolution of the network is controlled by the user. Top-level managers, for example, may choose to view up to 100 activities at the highest level of aggregation; if they desire, they may choose any one of these activities and then explode it into its constituent parts. Similarly, any one of these components may be expanded into a maximum of 100 of its constituents. Thus, a manager has the capability to move quickly up and down through the hierarchy of the network. Duration, time, and cost estimates were originally entered at the lowest level of aggregation; the computer then progressively summarized these to obtain values for each of the higher levels of aggregation. According to Douglas Seay,

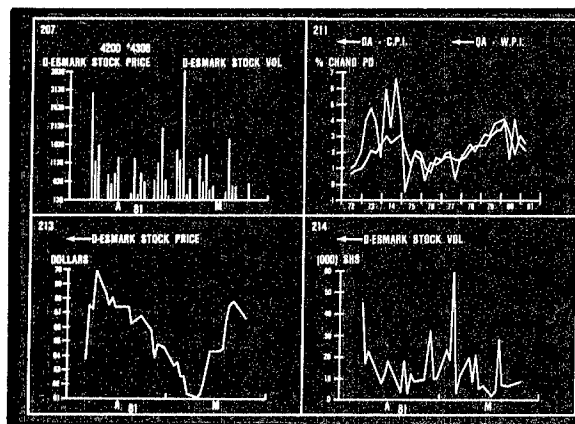


Figure 5: Esmark Stock Performance Analysis. Courtesy of Esmark, Inc.

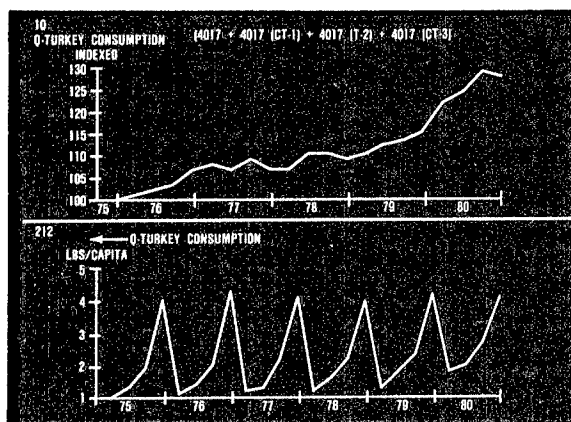


Figure 6: Historical Turkey Consumption from Esmark Data Base. Courtesy of Esmark, Inc.

Defense Systems Management College, interactive computer graphics have been shown in the Patriot Program Management Office to be an instrument of great potential value in project management. (11:32)

The technology of computer graphics may be an important instrument in the effort to stem the paper flood. In the applications which we have reviewed, we have found as a common element the desire to gain control of the deluge of data—the information overload with which many managers are struggling today.

A testimony to the worth of graphics is found in the words of George B. Blake, Vice President for Finance at Anderson, Clayton and Co.

Of all the frustrations of business life, surely one of the most aggravating and persistent is the flood of paper. Until a year ago, I used to update my mental portrait of the company by wading through a 100 page monthly budget report on the corporation, the divisions, the profit centers, and the products. To round out the picture, I also slogged through a series of smaller reports on collections, bank loans, and the like. These added perhaps 50 pages to my pile.

Now I get a better picture from just one sheet of paper. It has 20 small graphs on it. The graphic management that has evolved helps stem the paper flood and has resulted in many benefits, not all of them expected. (5:26)

Wherever major accumulations of information (data bases) occur and require periodic review, a potential application for computer graphics exists. A particular efficiency is realized when managers are granted direct hands-on access to current data through coherent displays generated almost instantaneously through computer graphics.

According to *Computer Decisions*:

Today computer graphics are found in companies with sales under \$1 million as well as the giant industries. They benefit from computer graphics in improved management of information, faster dissemination of information, improved design accuracy, and reductions in lead time. (5:35)

### **The Current Technology**

The current technology in computer graphics consists of three parts: the display terminal, hard copy equipment, and software. Display terminals are becoming increasingly powerful and sophisticated while their costs are either remaining constant or decreasing. Software enhancements are continually increasing the versatility of systems while at the same time simplifying their use.

The display terminal serves as the means of communication with the computer as well as providing for input/output. By direct communication with the terminal, either through a keyboard or a light pen, the user calls up and modifies various displays. Display terminals today are of two main types: storage tube displays and refresh displays.

Storage tube displays are the least expensive and provide a high resolution display with very little flicker. They are not continually updated; so in order to modify the display, the system must erase the entire screen and generate the whole image anew for even a slight modification of the display. Such systems are not suited to an interactive environment where numerous modifications of a display are contemplated. Storage tube displays are also unable to generate colors.

The general category of refresh displays can be separated into two subsets: vector refresh and raster scan. Each of these technologies has a selective erase capability which is facilitated by continuous redrawing (refreshing) of the display. Vector refresh technology provides a very bright, high intensity, high resolution image. It has, however, no color capability and can display a limited amount of data without flicker. Raster scan technology provides an inexpensive refresh capability with full color and the capability to mix digital information with video (analog) information. The disadvantage of raster scan is its relatively poor resolution which causes some lines to have a jagged appearance. Raster scan displays are becoming increasingly popular and, according to *IEEE Computer Graphics and Applications*, "will probably be the most cost-effective devices in many applications within a few years." (16:67)

Hard copy output equipment is capable of generating output on paper, microfiche, or directly on plastic for view-graph production. The three major types of equipment are pen plotters, electrostatic printers, and computer output microfilm (COM) equipment. Pen plotters use a conventional pen-and-ink technique to produce excellent quality graphics with color capability. Pen plotters are, however, relatively slow. Electrostatic equipment is faster. It provides good quality graphics using up to 200 dots per inch to produce images. It has

no color capability. COM equipment reproduces graphic output directly on microfiche. It provides the highest quality output and operates at the highest speeds. It is also the most expensive of the three hardcopy output devices.

Computer graphics software has experienced great improvements in ease and simplicity of use and in the sophistication of its capabilities. Many software packages, for example, now provide various choices of axes, such as linear, logarithmic, or polar. Many include a wide range of symbolic logic, such as Greek letters and mathematical symbols. Mapping and contouring programs are common features, as are packages with standard business-oriented applications. Three-dimensional plotting capability is now commonplace as is the capability to rotate three-dimensional images through space.

In the future, one would expect to see continued development and improvement of these capabilities, more advanced graphics and languages, and automatic graphic layout features. It appears the time is coming when the kinds of capabilities discussed above will be available to even low-budget operations.

### **Possible Concept for Base-Level Application**

We turn now to a consideration of possible applications of this technology to military base-level logistics management. For ease of comparison, this section is arranged in parallel with the earlier discussion of industrial applications of computer graphics. We will present first those ideas which are similar to the CAD/CAM applications described above. We will then present ideas related to management information using the same two categories as above: (1) those which depict geographic relationships and (2) those which present abstract management information in charts and graphs.

To begin with CAD/CAM applications, we must identify a logistics function that would benefit from the presentation of physical objects in three-dimensional perspective and the ability to rotate and manipulate these objects through three dimensions.

One such function is load planning (i.e., planning for loading or reloading of items onto cargo pallets and possibly for the loading of pallets onto aircraft). The standard cargo pallet is 104 by 84 inches across the base, with a height limitation determined by the aircraft type. Typically, a number of heterogeneous items will be stacked onto such a pallet. The pallet is loaded manually by iterative methods in an attempt to maximize the use of the available space. If the measurements of this pallet and its candidate load items were typed into a small computer with three-dimensional perspective, the items could be iteratively "loaded" onto the pallet by computer, possibly by moving the items with a light pen and rotating the picture to examine the fit. Certainly, if satisfactorily implemented, such a system would be preferable to repeated manual handling of these objects. The simplest conceivable such system would only take into account the shape of each of the items, leaving to the operator questions of the stability of the load and the best uses of the available space. There are, however, other parameters associated with both the pallet itself and the items to be loaded which might be included in the loading algorithms at the risk of adding some complexity to the implementation. Some pallet restrictions which could conceivably be included in the

application might be: total pallet load-bearing capability, maximum pressure (PSI) limitations, and pallet center of gravity (CG) limitations. Some characteristics of the loaded items which could be considered include: weight, weight support restrictions of boxes and crates (i.e., rigidity and strength), and identification of items designated as hazardous cargo.

The field of management information which can be presented through its geographical relationships leads us naturally to flight-line applications. The flight line, or any subset of it, might readily be represented in a computer graphics simplification.

One application which readily comes to mind is a representation of fuel storage and "tank farms." These might include in the simplest case only jet fuel, or in more comprehensive employments, representations of jet fuel, motor vehicle fuel, etc. It would seem to be reasonably straightforward to set up a computer graphics display of the various fuel storage devices and their interconnections which could automatically monitor the levels in each device, perhaps prompting an operator when levels occurred which required certain actions. More complex representations can easily be imagined, although they increase the risk and difficulty of the implementation.

Similar applications might be considered in the tasks of maintenance control and/or the scheduling of aircraft. In such an implementation it might be desirable to represent a simplified ramp space depiction, with each of the aircraft spots shown. It might be possible then to show a macro-view of the ramp which includes only aircraft tail numbers at each of the spots, as well as some gross indicator of each aircraft's maintenance and/or fuel status. Such gross indicators could be color-coded symbols to simplify the presentation. If additional information is desired, it might be possible to call up a different presentation which would be a micro-view of a single aircraft. Such a presentation might include more detailed status information, such as actual discrepancies and scheduling information.

A rather different application, but one which still falls in the same general category as above, might be the use of computer graphics in electronic troubleshooting. Here, we might see on the computer screen a color-coded schematic layout of a set of circuits or components of an aircraft subsystem. A technician might employ such a computer graphics technique to troubleshoot a system in much the same way that he now uses a technical order. Conceptually, it seems algorithms could be written in which the computer leads the technician through a step-by-step process of fault isolation and then correction.

The second category of management information is that sort of abstract information which is frequently presented in standard Cartesian-coordinate graphs. This kind of information is embodied in the base-level Air Force logistics world by the many management indicators which characterize the status of aircraft maintenance, the status of aircraft supply, the degree of adherence to the published flying schedule, the status of various technical orders and modifications, and a host of other measures of productivity and status. This kind of information resides in a maintenance management data base which requires frequent access, probably on a daily basis, so that graphic presentations may be manually constructed to summarize the information for presentation to higher management. Certainly this procedure is very much like that of several

corporations we have reviewed. The commonalities are: (1) an automated data base which contains information from which performance indicators are derived, (2) frequent access to the data base to extract information for management, and (3) construction of graphics which summarize the information for presentation. The difference is that companies such as Gould, Inc., Phillips International, and Esmark have essentially automated this entire process so that their managers and board rooms are connected directly through simplified computer graphics with the data base which constitutes their source of decision-making information. These companies report great satisfaction with their systems. Whether the Air Force manager would benefit from such a system is a subject which calls for study.

### Considerations of Cost/Effectiveness

We have discussed the uses of computer graphics in the corporate world, the nature of the technology which is available today, and some possible applications of this technology to base-level logistics management tasks. We now turn to a brief but important discussion of the analysis which must precede adoption of any such systems.

The first and most fundamental point is that one should not assume that a system which incorporates more advanced technology is *a priori* better than its predecessor. It is essential that we expose the decision process to some reasonably rigorous form of cost-effectiveness analysis. Unfortunately, the structure of these analyses (for purposes of selection of computer systems) is usually not well defined. An article by Ira Cotton of the National Bureau of Standards documents the difficulties of such analyses; the major difficulty is that of establishing and measuring the benefits of the system. (4:37)

We may recall from the introductory paragraphs of this article the recent increases in capitalization of administrative workers from \$2000 per worker to \$10,000 per worker. Consider this figure, which implies a pervasive automation of administrative work, and the many examples of implementations of computer graphics which we have discussed. One might suspect that such major movements toward automation would have been justified by some cost-effectiveness analysis. It may be of value to review in more detail some of the corporate applications discussed, with the purpose of understanding precisely what criteria of cost and effectiveness were used in the adoption decision.

There are a number of measures of effectiveness which we might consider in any analysis of computer graphics systems. These include: production rates per labor hour, quality and timeliness of reports, reduction in media transformations, improved information flow or decision turnaround time, improved management planning, and reduction in crisis behavior. All but the first of these present some obvious difficulties of measurement. And yet, given that one can establish some measure of these indicators, there is the additional problem of insuring that improvement in one of these indicators is favorably related to some measure of final output such as—sorties per day.

We hope through the work involved here to stimulate further thought and discussion concerning the applicability and relative effectiveness of graphics systems in the field of base-level Air Force logistics management tasks. Future productivity demands our present attention: we should do no less.

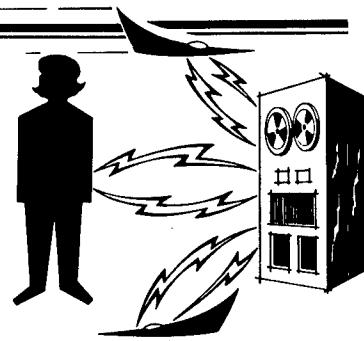
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## Integrated Maintenance Information System: An Imaginary Preview

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### Prologue

The hour just before dawn is dark, with just a promise of the light to come. The flight line, packed with remotely piloted vehicles (RPVs), is slowly coming to life. Small vans are fanning out from the maintenance building. They will transport maintenance technicians to the scheduled aircraft.

Sgt Bayshore is crew chief of RPV #007. She is just preparing to preflight her RPV for a mission. Let us look over her shoulder as she works.

### Action

Unfastening a panel on the left side of the fuselage, Sgt Bayshore exposes the control and display panel for the central computer system. She inserts a small cartridge and then turns on the aircraft battery power and punches a button marked "Preflight System Checkout."

Turning, she begins her visual inspection of the airplane. Finding nothing wrong, she returns to the panel where the navigation correctional unit is identified as being in a deteriorated condition.

By selecting the appropriate button, she quickly receives additional specific information about the deteriorated condition. She agrees with the recommendation of the computer to remove and replace (R&R) the unit, so she requests R&R instructions. She finds that the task is assigned to the crew chief; she identifies and opens the appropriate panel and quickly removes the unit. The panel is now flashing a warning in red that the navigation correctional unit is removed.

Taking a small wand from a small radio device on her belt, she passes it over the supply information displayed on the screen. Thus, she places the requirement for a spare with the local supply center.

While she waits for the part to be delivered, Sgt Bayshore calls up the RPV records on the computer display. An aircraft wash is due in three days; weapon system certification is due in a week. The few items still requiring preventative maintenance are listed and some sheet metal work is scheduled for tomorrow. The flight schedule indicates a heavy month of flying is planned.

She checks the Recent Change List: No major changes in technical order (TO) procedures, monitoring requirements, or performance standards have occurred in the past three days, so she is current on everything.

With everything stored on the cartridge and the cartridge updated at the end of every day, it is not difficult to keep up with changes. The daily cartridge update also dumps the day's collection of historical data, flight information, and condition monitoring data into the central computer system for this RPV module.

The cartridge system works very well, but it is out-of-date. The cartridge has to be handled every day in this system. Sgt Bayshore will be glad when her squadron gets the new system which does not use the cartridge.

The new system communicates directly with the local maintenance computer center for update and data dumps. New developments in telemetry technology make the procedures trouble free and efficient. The system will make information available to the RPV computer system as it occurs. It will instantaneously update the maintenance and operations information system for planning and scheduling purposes.

Sgt Bayshore quickly exchanges the old unit for the new one and plugs the new one into the appropriate receptacle. The computer senses the changes, makes its check, and then flashes an "all systems go" signal on the display screen.

Just in time—the Flight Operations van approaches. Sgt Bayshore gives the thumbs up signal to the driver as he passes. The van stops nearby in a position to control the movement of all the RPVs as they taxi toward the runway.

Soon, Sgt Bayshore hears her RPV #007 being called on the portable radio on her belt. Time to fire it up and send it off. Quickly, she does so, checking the computer display panel one last time before she steps back and tells the Operations van controller that #007 is cleared for taxi. She watches as the RPVs make their way like robots to the end of the runway and then take off into the early morning light.

Time for a break—the RPV is in the hands of the pilot in the van for the next two hours. Sgt Bayshore has been on the flight line for less than 30 minutes. Not bad—that is the 42nd on-time takeoff in a row without an abort. The last abort came when she disagreed with the computer, thinking that one more flight was possible. Oh well, she was new then—now she has learned to trust the computer.

After drinking her coffee, Sgt Bayshore decides to go to the local maintenance computer room to find out more about this system. On her way to the computer room, she passes offices containing the maintenance planning, scheduling, and analysis functions. Display terminals tied into the local maintenance computer system have significantly improved the timeliness and

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\*This paper was presented by the author at a symposium on "Product Support—A Changing Challenge" in Seattle, Washington, on 21-22 October 1980. The symposium was sponsored by the Aerospace Industries Association and the government. The paper was a portion of a panel on "Publications—A Look to the Future." The paper was also presented by Ross L. Morgan at a DOD/National Security Industrial Association (NSIA) conference on "Personnel and Training Factors in System Effectiveness" in San Diego, California, on 6-7 May 1981. The author and Ross L. Morgan are associates at the Logistics and Technical Training Division of the Air Force Human Resources Laboratory at Wright-Patterson Air Force Base, Ohio.

accuracy of the information required for day-to-day management of the maintenance organization.

With a wave, the computer center operator motions for Sgt Bayshore to come in. The computer room is small, clean, cool, and quiet. The operator explains the system to Sgt Bayshore in detail.

This small local computer is dedicated to maintenance, and it provides all of the computer support the maintenance organization needs. It runs the maintenance management information system, with terminals in all work centers. This includes scheduling, controlling, analysis, records, training, and mobility, as well as all status and management reporting systems.

After all the bugs had been worked out of the system, the support staff workload had been reduced and several people have been reassigned to maintenance jobs in the various squadrons. These actions enhanced in turn functions such as training and supervision, and increased the number of people assigned to sortie-producing tasks.

Of course, the local computer is also the interface for the weapon system central data computer at the Air Logistics Center (ALC). This interface makes technical data available to the bases and inputs historical, trend, and operations data to the central data base. All technical order information is stored in the central computer and transmitted to the local computers for temporary storage and distribution. Distribution is made to the technicians through cartridges for the aircraft, through plug-in, portable units for work away from the aircraft, and through direct link with the terminals in the shops.

Under mobility conditions, the local computer can operate in a stand-alone mode. It will perform all of its normal functions plus providing its own "central data bank" functions. If satellite data links are established at the new operating location, the computer can revert to a local computer tied to the central data bank or can continue to operate independently. The computer is designed for mobility conditions and requires only minimal attention to a controlled environment and special handling.

Technical data are virtually untouched by human hands. The prime contractor prepared the data within his own computer system according to the government specifications. Task analysis is managed by the system to insure quality and thoroughness. Updates and changes are made easily and quickly. After validation and verification are complete, the data, including graphics, are input to the central computer data bank for that weapon system at the responsible ALC.

All engineering changes, corrections, etc., are managed by ALC personnel. When a change is required, the Air Force requests the work be done; and the contractor completes the work and inputs the change to the central computer at the ALC. The central computer stores, updates, and manages all of the technical data system.

The central system has an artificial intelligence capability that permits it to learn from the troubleshooting successes and failures of the built-in system in each RPV. As the successes and failures are combined and analyzed in the central system, the artificial intelligence capability makes necessary adjustments in the troubleshooting strategy and programming. Thus, it provides the most current information to a local computer in an instant.

For each RPV, there is a small cartridge that contains

the information that previously was contained in the aircraft records and in the TOs for the aircraft. This cartridge is plugged into the central computer system of the aircraft whenever it is flying and whenever maintenance is being done.

At the end of each flight and maintenance day, the cartridge is removed and plugged into a receptacle in the local maintenance computer room. This dumps the accumulated flight operations data, historical action taken, aircraft records data, and trend data. This information feeds the maintenance management system. While the cartridge is plugged into the receptacle in the local computer room, the central data bank is queried; and if the cartridge does not contain the latest technical information or performance parameters, the update is made.

Sgt Bayshore is very familiar with the portable technical order device. Weighing less than two pounds, the small 7- by 3-inch device incorporates a radio for communication with her supervisor, an optical character reading wand to order supplies, and the display screen, removable input keyboard, voice recognition, audio microphone and speaker, power pack, and data storage.

Self-contained, rugged, small, and lightweight, this one device is a technician's most prized possession. It provides technical information in either video or audio form, or both. It contains graphics that were available only on bulky graphic systems just a few years before, and it incorporates a training mode that permits review or on-the-job training (OJT) whenever and wherever the user chooses. The voice recognition capability and the extensive interactive capability allow users to ask technical questions and receive answers as if a very experienced senior technician were personally tutoring them.

Like the cartridge for the aircraft system, this device is plugged into a receptacle in the local computer room for daily update of the TO information and to dump historical data input by the user. It is used for work away from the shop or aircraft and where it is not convenient to keep referring to the aircraft panel display. It can be hand-carried, fastened to a belt, or carried on a shoulder strap.

The computer operator explains that the remaining portion of the system is found in the intermediate level shops. The shop device is a combination of automated test equipment (ATE), automated technical order system, and instructional system. The display screen is large, 32 inches by 32 inches, and provides unbelievable clarity for both text and graphics. An input alphanumeric panel provides total input flexibility and may be extended to 15 feet away from the screen. When a component is hooked up to the device, the proper check is run automatically; and the results are displayed instantaneously.

When appropriate or when requested, additional troubleshooting information is displayed. All information required for any task performed on the component is displayed when requested.

The system also includes a training capability to provide individualized instruction, along with a testing, evaluation, and tracking capability for a great number of students. A built-in projection capability can support a classroom and group maintenance environment.

Being able to support several terminals itself, the device thus can be active in any or all of its three modes simultaneously.

It is fully deployable to remote locations and requires minimum facilities. Each shop device is linked to the local computer and is updated whenever changes are input to the control system. Thus, the ATE, TO, and training materials are always current.

A few words about the type of technical data are appropriate. The information, including script and supporting graphics, is stored digitally in the central computer. The user can choose from several formats, ranging from the most detailed step-by-step procedure to animation-type graphics without text. Several levels of detail are offered, virtually insuring that any given need can be met. Remedial training, quick review, or detailed theory can be provided when requested.

The graphics are most impressive. In full color, fast, and fully interactive, they can provide rotation, layering, and three-dimensionality with animation to meet all needs.

The audio output, voice recognition, tutorial and interactive modes, and the artificial intelligence aspects make the system tremendously flexible and effective. Extremely simple input requirements and complete fulfillment of the informational needs of the technician have insured user acceptance.

Sgt Bayshore still has nearly 45 minutes before her RPV is due back. She finds a comfortable chair in the crew chief's lounge and turns on her portable TO device. Reviewing the table of contents, she asks for the theory and operating characteristics of the new terrain-following bomb-navigation system just installed last week. She has decided to get caught up on the new technology and speed her professional development.

Later, after hearing the return of her RPV announced on the radio, Sgt Bayshore is waiting as #007 returns to its parking spot. Postflight is a virtual repeat of the preflight with the computer announcing that no failure occurred. She adds some fuel, checks the tires, launches and recovers again, and then she can go home. These six-hour days are not bad. It is no wonder there is a waiting list to get on the flight line.

### Summary

Let me summarize my major points. First, I obviously believe that there should be a system, *not* several, composed of the following:

- a weapon system computer
- a local maintenance computer
- in-shop terminals
- flight-line information device

- information module for each RPV
- RPV display, controls, and computer

This system consists of a local computer that is tied into a weapon system specific computer located at the appropriate ALC. This permits the local system to be updated with the most current technical data and the weapon system computer to be updated with historical and trend data from the base.

The local computer powers the in-shop terminals, each of which can support satellite terminals for training and evaluation purposes. It also updates the portable device and the RPV module.

The flight-line device is small and performs multiple roles. It contains technical data with graphics, a training mode, a radio, an audio capability, an optical scanning wand, and a voice recognition capability.

The RPV has a plug-in module that contains technical data, operating parameters, checkout and troubleshooting information, a data collection capability, and a training mode.

The RPV display, controls, and computer provide interactive capability through the RPV module while installed on the RPV.

### Epilogue

Together these components:

- Store and present the technical data, including checkout, troubleshooting, and "learning" mode. Updated on a daily basis, the information is always current. Designed with the needs of the user in mind, the data are more accurate and usable than ever before. Inputs are made directly from the contractor's facility, and quality is up and costs are down.
- Provide a training capability, including review, OJT, and evaluation.
- Provide inputs to the maintenance management information system via the local computer. Impacted are Job Control, Plans and Scheduling, Records, Materiel Control, and Maintenance Analysis functions.
- Gather historical and trend data via the system. Data are input through the local computer to be stored at the ALC.
- Provide a radio link to maintenance, supply, and operations.
- Are fully deployable to remote locations and, in the case of the flight-line device, comfortably portable.

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### *Most Significant Article Award*

The Editorial Advisory Board has selected "Strategic Materials: An American Achilles' Heel" by Major Cecil J. Smith, USAF, as the most significant article in the Spring 1982 issue of the *Air Force Journal of Logistics*.

## Integrated Wartime Supply

Captain Andrew J. Ogan, USAF

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### Introduction

In modern warfare with evermore complex weaponry and sophisticated equipment, the ability of armies to move effectively in the field relies heavily on a responsive logistics system. Historically, the U.S. logistics system has responded well to the nation's needs by providing enormous quantities of supplies at locations throughout the world whenever the need for sustained military operations arose. Over the past several years, however, the ability of the U.S. military to successfully carry out military campaigns has not only been questioned but vigorously challenged. While the challenges have taken many forms and addressed varied issues, the central theme questions the ability of the military logistics system to rapidly and effectively support the employment of forces. Even though past conflicts have been logistically supported, often the quality of that support has been certainly less than optimal.

The major thrust of this article, then, is to examine the wartime supply system and the one organizational entity that integrates its operation—the National Inventory Control Point (NICP). It is apparent that wartime conditions under which the NICP once successfully supported operations have changed in a way that materially affects the ability of the NICP to continue wartime support. The conclusions reached indicate the need for greater functional integration within the NICP through what must be major organizational revisions.

### Wartime Supply Network

The wartime supply network consists of three major levels—the defense industrial base or contractors, the wholesale management level or NICP, and the retail level units or the field operations in the theater of conflict (Figure 1). Each of these levels is connected by the transportation and information management systems. The transportation systems are responsible for the flow of materiel, while the management information systems provide contract and specification updates and requisition information. As seen in the figure, the center organization, the NICP, controls the information and property flow to each of the other operations. The defense industrial base and the field level units rarely have any contact with each other. They rely on the NICP organization to communicate and manage their joint interests. Because of the control this organization exerts over the entire logistics structure, the effectiveness and quality of wartime supply support are determined largely by the NICP.

Since the NICPs collectively control the materiel flow from the defense contractor to the field level units, they must centrally procure the food, spares, and equipment and then distribute this materiel to the base level units. It is also within this organizational entity that a great number of maintenance actions take place. What the base level organization receives, how quickly it is received, and in what quantity are determined by the internal management operations of the NICP. Clearly,

\*This article is a follow-up, requested by AFJL, of Capt Ogan's and Lt Col O'Neill's well-received contribution to the *Defense Management Journal*, 4th Quarter 1981.

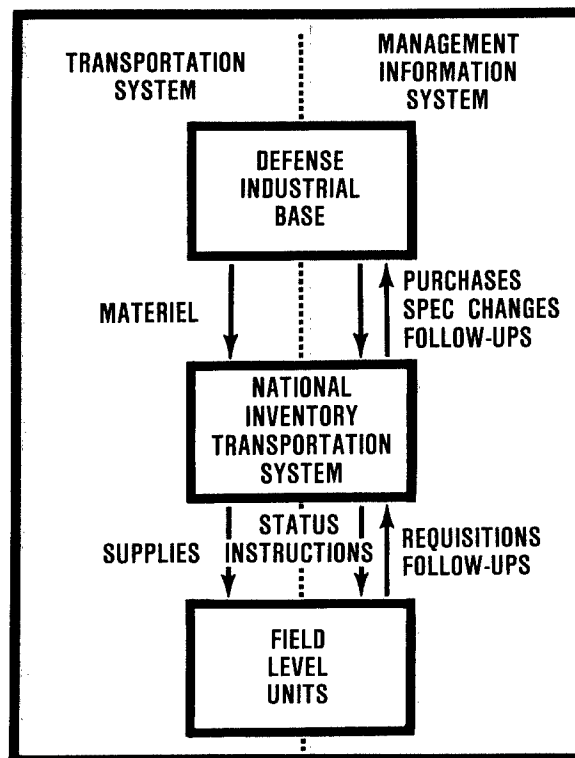


Figure 1: Wartime Supply Network.

how the NICP reaches its decisions, as well as the amount of time and coordination required to make those decisions, determines to a great extent the support given field units.

### NICP Organization and Problems

The NICP organization is functionally aligned, that is, divided into several major operating entities, each contributing to the overall mission. Although other elements such as manufacturing or maintenance (as in the case of the Air Force Air Logistic Center (ALC) organizations) may be colocated, the functional elements of the NICP itself usually consist of a supply unit, an acquisition unit, and a technical unit. Though specific titles and structures within the individual elements may vary, the functional areas tend to be subdivided along commodity lines, with a management information system supporting this substructure and interfacing with colocated units (such as the ALC maintenance structures).

Each of these functions operates independently of the other, yet the product from the NICP relies on the successful operation of all the NICP functions. The problems with these internal operations are, first, that all the means to provide wartime supply support are not contained in any one function and, second, the "completed" job within each of the functions occurs not when the customer receives his part but when a properly completed piece of paper leaves one functional area headed for another. Therefore, the more visible problems of lack of goal congruency and organizational barriers arise out of these two areas.

To overcome the influence of conflicting factors that may fall outside its control, each functional area in a typical NICP appears to have developed objectives designed to measure its functional performance somewhat independently of the other disciplines. For example, supply may have a certain customer "fill rate" as its primary goal and minimizing back orders as a secondary goal. Acquisition may have as its primary goal a designated number of contracts awarded and may give second priority to minimizing administrative lead time. The two sets of goals may only appear to be mutually reinforcing. In practice, any pressure or priority that supply may impose toward improving the fill rate may, in fact, only detract from acquisition's goal of reducing administrative lead time. If each element tries to force the other to divert resources to satisfy a particular goal, organizational conflict results.

Sometimes, the conflict of goals has led to the formation of communication barriers between functional elements. To protect and insulate each function from the demands of others, the communication process often becomes more formalized. Such barriers usually require additional coordination with more and higher levels of management within each function. To deal with these functional conflicts, managers at the various NICPs have developed and implemented various quasi-formal and informal structures designed to cut across functional lines and integrate the efforts toward overall goal achievement. This circumvention of the formal organization illustrates the problems of working within the existing NICP structure and questions the validity of the current structure.

### NICP Wartime Support

The NICP operation, in previous wars, has relied on the tried and true maxim of getting there "fustest with the mostest." Each of the functional elements within the NICP worked to acquire and then distribute to the theater as much property as possible. The typical pattern of NICP support for wartime units is known as the "push" system; i.e., distributing in advance of known requirements those materials required to sustain forces. However, this system remains effective only when two logistics conditions are met: there must be an abundance of materiel and there must be ample time to acquire and move additional materials.

In World War II, the troops in each theater operated with an abundance of property. That abundance is best illustrated by a Bill Mauldin cartoon (Figure 2). Although we were at war with Germany and Japan, we also operated with a time cushion. It took time for our enemies to mass troops and ships and to acquire the necessary supplies. Consistently, that cushion worked to our advantage in wartime supply. The North Africa campaign, for example, was delayed largely due to logistics problems. Stocks shipped to England to support this effort were lost in the large push of supplies from the United States. Duplicate shipments were required from stateside before the campaign could begin. We had the time to wait and the materiel to provide duplicate quantities. In Korea and Vietnam, we were able to control, for the most part, the timing and scope of the conflict. Supply problems could delay battles without serious problems. In all of these wars, the NICPs generated mountains of supplies and pushed them into the theater. Duplicate shipments were not uncommon and sometimes necessary to ensure that the combat forces received essential supplies.

The two conditions under which we have operated for



Figure 2: Those were the days.

so long have changed. Funding limitations over the past several years have reduced the available supplies and created a number of "critical spares"—classified as such because of the small numbers purchased. These funding limitations have also contributed to the decline of the industrial base by reducing the number of contracting instruments as well as the dollar size of the remaining contracts. The NICPs no longer have the assets available in great quantities nor do they necessarily have the industrial base with which to generate a large number of assets quickly.

The time element has also changed. Where we once relied on sealift to fulfill all requirements, we are increasingly turning to airlift to meet many of our needs in the opening phases of a conflict. Rather than locate stocks at forward locations, we anticipate airlifting them into the theater quickly. This increases the immediacy of wartime supply and also the necessity for the NICP to more correctly identify what stocks are required and where—and then to acquire and distribute those stocks.

These two conditions are intertwined; but, collectively, they severely impact the way we have done business. With an abundance of materiel, we could locate stocks where we anticipated a conflict in sufficient quantities to give sealift time to respond. Without the abundance, we need a faster response time to theater requirements.

### Integrated NICP Management

To operate effectively with these changes, the NICP must be able to acquire stocks and respond to command direction more quickly than ever before. The functions within the NICP must begin to work in concert rather than in competition with the other disciplines. In effect, we must shrink the amount of coordination and internal functional realigning that takes place to support a conflict. We believe this can best be done by improving goal congruency, reducing the communication network, and improving the command and control structure. The approach that we favor is the

development of a materiel management organization (Figure 3).

The basic changes in the standard NICP organization are the development of commodity branches which contain the technical, supply, and acquisition functions that support an individual commodity. This change will organize those elements responsible for the performance of the NICP along mission rather than functional lines. Such an organization establishes both the responsibility and authority for mission performance at the lowest practical level, thereby fostering goal congruency among the functions and reducing many of the communications problems. Those elements performing administrative, professional, or system management services would matrix across the organization.

Integrated management provides a focal point for management resolution of support functions. The commander of the NICP who is responsible for the overall performance of the organization will have more effective command and control. Problems within a commodity group can be identified and resolved within the organization itself.

Support problems relevant to individual weapon systems can be more easily addressed by the system managers under this revised organization. Currently, the system manager matrixes across the organization in an attempt to identify what is wrong and who is at fault. However, the decentralized decision-making on weapon system support makes it difficult to identify what decision is actually impacting weapon system support. The commodity organization gives the system manager a focal point for resolution of support problems related to his system.

An integrated support concept similar to the one proposed here was tested at the Defense Construction Supply Center (DCSC). While the DCSC test was much more limited in organizational impact than the one proposed, there was improved performance where the revised organization was employed. DCSC summarized the test results as follows:

In conclusion, the data and statistics gathered before and during the test indicate that overall the test group improved in those areas in which data was gathered and generally outperformed the various control groups. As the factors affecting the test were kept to a minimum, improvements with this magnitude and scope can only be attributed to the effects of the ICP Operations Management Concept.

*Defense Management Journal, 4th Qtr 1981*

## Conclusion

The success of modern military operations is dependent more today than ever before on a responsive, integrated supply system. The luxuries of a time cushion and ample materiel reserves that we enjoyed in the past no longer exist. Now, the wartime supply system must support field level units more quickly but with less reserve stocks and reduced industrial capability. As the integrating agency in the wartime supply system, the NICP must quickly assess the impacts of these changes and resolve them. This demands a more responsive system in which internal NICP functions are operating to integrate activities with minimum communications and goal congruency problems.

The introduction of a revised NICP organizational structure can improve NICP responsiveness in two major areas. First, a commodity-oriented approach to wholesale management provides the opportunity to integrate within each of the commodity areas the entire functional family of support. These commodity groups become mission rather than functionally oriented. Communication and goal congruency problems are greatly reduced or eliminated. Second, command and control of the entire NICP organization is strengthened. Both the commanders of the NICP and supported commands and the system managers have a focal point within each commodity where the support problems can be resolved or clearly identified. It is with this type of focus that they can all work together toward integrated wartime support.

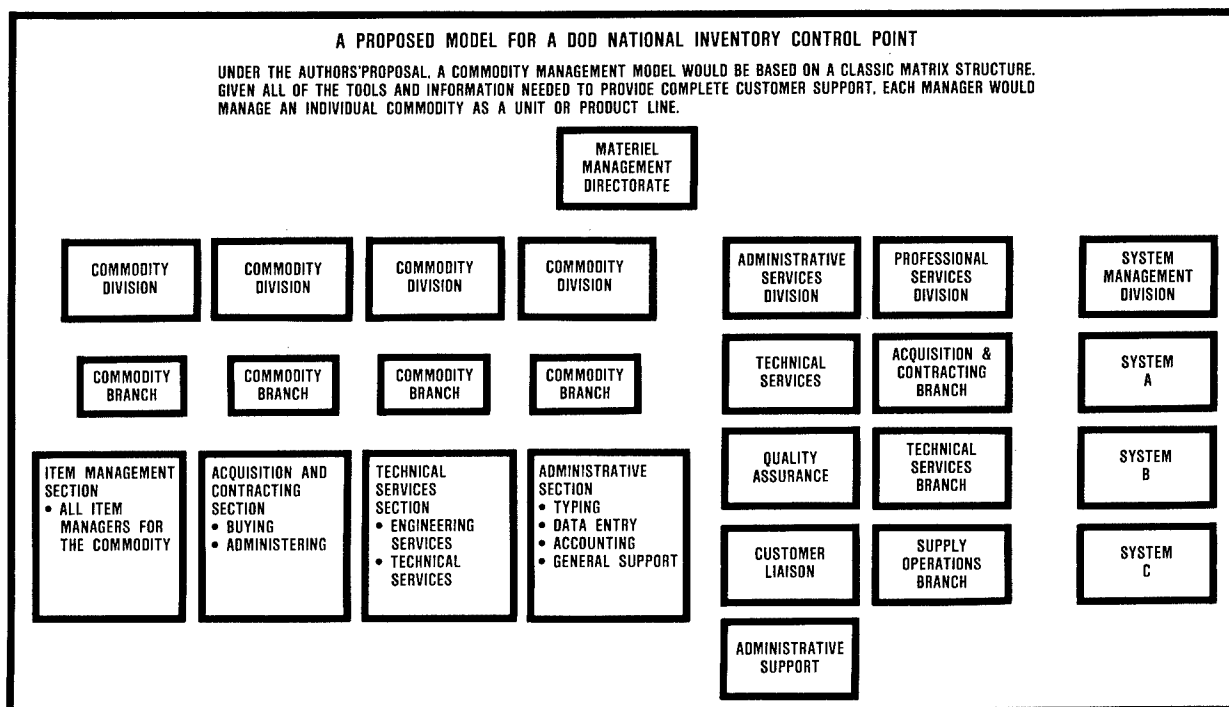


Figure 3: Proposed Materiel Management Organization.



# CAREER AND PERSONNEL INFORMATION

## Civilian Career Management

### Logistics Civilian Career Enhancement Program (LCCEP)

The concept underlying the Air Force Logistics Career Program, proposed by Mr. Lloyd K. Mosemann II, Deputy Assistant Secretary of the Air Force for Logistics, was to address a number of problems which related directly to the career of our *logistics* civilian work force. Mr. Mosemann, as well as other senior AF logisticians, recognized that the Air Force had its share of good civilian logisticians but that they could be better prepared to cope with the logistics issues of the future. The basic theme of this program is that LCCEP was developed for and is administered by logisticians in coordination with the personnelists.

One of the primary objectives of the LCCEP program is to provide the Air Force a source of top candidates for career program position vacancies. This is done by progressively developing higher potential logisticians for senior level jobs and providing expanded visibility on career opportunities to other individuals.

Essential to the operation of the LCCEP is the Personnel Data System - Civilian (PDS-C) which contains the personnel records of all Air Force employees. The information provided by the PDS-C is used for total work force management and career program support.

Since the inception of the LCCEP, there have been over 208 position vacancies filled throughout the logistics community. Before a position can be filled, a Promotion Evaluation Pattern (PEP) must be prepared. A PEP is based on detailed job analysis of the position and states the skill codes and occupational series that have been identified by logistics functional management as representing the knowledges, skills, and abilities (KSAs) necessary to perform the duties of the positions. All LCCEP PEPs are used in the Central Promotion and Placement Referral Subsystem (PPRS) of the Headquarters Air Force (HAF)-level PDS-C. When the Logistics Career Program Office receives a request to fill a position vacancy, employee records in the PDS-C are automatically scanned by the PPRS using the proper PEP to identify those people who have the skills which qualify them to perform the duties of the position. Also, OCPO/MPKCL provides microfiche copies of LCCEP PEPs to all Central Civilian Personnel Offices (CCPO). A booklet on definitions of skills codes used in PEPs is also available at the CCPO.

A Career Brief, which can be obtained from your servicing CPO, is another valuable aid. It gives you a snapshot of your work history. It tells you what is in the PDS-C now in regard to skills, occupational series, time in grade, etc. Any suspected errors in your Career Brief should be resolved with the Employee Development Specialist at your CCPO. Once you have reviewed your Career Brief and know what is in the PDS-C, both short- and long-term goals need to be set. To do this, you will use three career management tools: the Individual Development Plan (IDP) (AF Form 2674), the Master Development Plan (MDP), and the Career Patterns in AFR 40-110, Vol IV (25 Sep

81). The first step in filling out your IDP is to thoroughly review AFR 40-110, Vol IV, Attachment 3, Master Development Plans. This attachment is a guide to experience, training, and education desirable for progression in the logistics career field. Next you need to review AFR 40-110, Vol IV, Attachment 2, Introduction to Career Patterns. Logistics career patterns are standard, stable networks of Air Force positions within each logistics career family, showing possible progression paths and reflecting the sequence of job exposures. They can be used by you to plan experiences which will enhance your development as a logistician to achieve career management and personal career objectives. The IDP is finalized when approved by functional management. The original is then forwarded to the servicing CCPO where it is used as an input document to the PDS-C and then filed in your official personnel folder (OPF).

In the process of developing logisticians who are fully qualified to meet the broad responsibilities of high grade logistics positions, two general areas of development are emphasized. The first is obtaining multi-functional, multi-level, and multi-command experience relevant to logistics. The second is long-term training and education which provides managers with a broad perspective and the academic tools needed to better operate in our increasingly complex environment. The LCCEP will exploit these objectives by encouraging employees who plan to move into the management ranks to show personal initiative and achievement. In fact, selection into the critical core of logistics managers who will fill the senior management positions in the future will be predicated on individual demonstrated performance.

### LCCEP ACTIVITY (1 OCT 81 - 31 MAR 82)

	Cadre Reserved	Career Essential	Total
CERTIFICATES ISSUED	41	46	87
Selections:			
Cadre	31	10	41
Non-Cadre	8	27	35

NOTE: Of the 41 Cadre selections, 38 were promotions and 3 were lateral reassignments. Of the 35 non-Cadre selections, 33 were promotions and 2 were lateral reassignments.

Source: OCPO/MPKCL Randolph AFB TX

## Comments by Mr. Mosemann

*How is the LCCEP program progressing in relation to your expectations? Is the program attracting the best-qualified candidates? What, in your judgment, has the program accomplished so far?*

My expectation has always been that the LCCEP program would, over a period of at least a decade, produce individuals for our senior management positions who are more qualified in terms of logistics knowledge; who are more skilled in the use of advanced management techniques; and who, generally, are more inclined to be creative and innovative. We are looking for the development of individuals whose ideas and opinions will enhance both productivity, as an ingredient of enhanced readiness and management effectiveness, and economy. It is somewhat early, after only about two years in operation, to assess whether or not we have achieved that goal. Our expectation has always been for the real payoff to come in about a decade.

However, I am encouraged because we are attracting the best-qualified candidates, including not just individuals who might have been promoted anyway, but those who might not otherwise have been selected (10% to 20%).

The program has accomplished several things thus far: It has, for the some 1436 key positions managed under the formal LCCEP structure, resulted in the development and publication of standard, regular, consistent promotion evaluation patterns (PEPs). I can honestly say that, if the program were to be disestablished tomorrow and the PEPs retained, all the blood, sweat, and tears would have been worth it.

However, the program has actually produced more than just PEPs. It has created an awareness that: (1) we need "quality" in our professional civilian personnel, (2) formal education does make a difference with respect to management capabilities, (3) an individual who has experience in more than just one or two narrow functional specialties is of more value to the Air Force and to the Air Force logistics community, and (4) we are attempting to introduce a concept of merit and objectivity into our career management and related promotion and educational training processes.

I do not believe that we will ever have a program that is 100 percent meritorious, nevertheless that should still be our objective. In LCCEP we have provided the qualifications for those who rise to senior management positions, as a goal or a standard for achievers at all levels from GS-11 to the top.

*What new or improved controls are in work for the LCCEP to prevent it becoming a "buddy system"; i.e., only those providing blind allegiance to a few in power have a chance for cadre selection? Are all scores set by the few based on a personal patronage system?*

It seems to me the most "serious" opposition to the LCCEP program has come from those supervisors, or those employees, who see the LCCEP program serving to undermine those local "buddy systems" that may now exist. I believe that if the many problems associated with geographical moves did not exist and if there were a greater opportunity to select people from out of the local geographical area, then the demise of the "buddy system" would be even more evident than it is.

But the "buddy system" is not always bad. If by the "buddy system" you mean that an astute, forward-looking supervisor has identified people as potential successors to himself, and is taking steps to groom, to broaden, and ultimately to see that they are the best-qualified people to take his position, this represents a fulfillment of the LCCEP objectives.

Since there are good aspects to the "buddy system," I believe that the LCCEP program will be a positive reinforcement. We have provided guidelines, criteria, and targets for the supervisor to measure

his protege against. For example, if the protege is limited to some extent, the supervisor can initiate actions to broaden his background. If he needs additional education, the supervisor can initiate actions to motivate him in this direction.

We do not ever want senior managers, who identify the future leaders, to divorce themselves from that process. What we do want to accomplish through the LCCEP program is to establish a framework within which senior managers can function to assure consistency and equity across the *total* range of the Air Force logistics community.

Concerning the setting of scores, we are moving to implement changes in our cadre selection process, effective with Cycle 3, which will eliminate our dependence on appraisal "scores." Instead, we are moving to broaden the influence of Air Force-wide selection boards. As you may be aware, we currently have a single Air Force-wide board that selects GS-15 personnel. Last year we had two Air Force-wide boards that selected GS-14 personnel and a series of regional Air Force-wide boards that selected GS-13 personnel. These boards ensure that the interviewers are not necessarily the same individuals with whom a person works and, therefore, can bring objectivity into the interviewing process.

*Are there any future changes planned for LCCEP?*

At the forthcoming meeting of the LCCEP Policy Council, there will be several changes discussed. The most significant of these will be the abandonment of the MPA (Management Potential Appraisal) Form in favor of giving greater weight to the interview process for the selection of individuals into the cadre.

We are open to suggestions for change and have received letters from a number of individuals in the Air Force logistics community. But we do consider it a progressive program, one that is there to meet real needs, for both individual career logisticians and logistics managers.

At the same time, I should like to emphasize that whatever changes we make to the LCCEP will be consistent with our basic goals and objectives. We do not intend to restructure the program in a way that individuals will feel they have been "double-crossed" after having made commitments to self-development or to changes in career direction with the incentives of the LCCEP program in mind. We certainly would not want to make any radical changes which would alter the prospects for those individuals. Most of the changes that I foresee are mechanistic in nature; e.g., they will streamline, improve, or refine the mechanisms of the process.

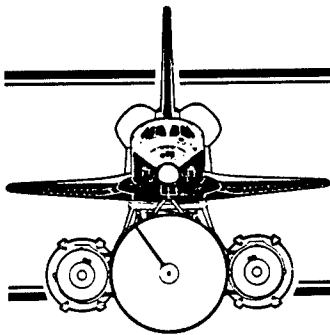
I think it is important, also, to note that the LCCEP program is not just for cadre members. All individuals who have registered in the inventory stand to benefit. For example, in FY81, of the 125 individuals selected for positions under the LCCEP program, about 40% of the individuals selected were non-cadre. Clearly the incentives of the program are structured to provide advancement for persons with broad-based, multi-level, multi-functional experience, regardless of whether or not they are selected into the cadre.

I believe that in time we will probably see more cadre personnel being selected for these positions, since the better qualified people will be in the cadre or close to the cadre. Our statistics bear out that there is plenty of opportunity now, and in the foreseeable future, for individuals who have not been selected into the cadre to be recognized and promoted.

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### Editor's Note:

The Military Career Management Department does not appear in this issue due to a lack of good relevant material. The Contributing Editor promises to return next issue.



## The Space Shuttle—Logistics Challenges

Lt Colonel James L. Graham, Jr., USAF

Office of Space Transportation Systems

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### Abstract

*A major program goal of the Space Transportation System operations phase will be to fly and refly the system with economy, but that goal may prove difficult to attain. Efforts have begun to define and start acquiring the hardware, logistics capabilities, and support systems needed for operations. However, the very success of the logistics concept used in development has tended to delay implementing true operations logistics support. NASA and the DOD face numerous challenges in Shuttle logistics, maintenance, hardware support, credibility of requirements, limited life hardware, integration of management, and competition for resources.*

Each time the Space Shuttle Orbiter touches down after another successful mission, the United States is a step closer to a fully operational reusable Space Transportation System. The concept of spacecraft reuse was articulated in the late 1960s and has now been successfully demonstrated. A major program goal is to fly and refly the system with economy—in dollars, in manpower, and in time expended between missions. NASA and the Department of Defense are partners in the program, with the Air Force as DOD executive agent. Our common goal of economy in Shuttle reuse may prove as difficult as was the earlier development.

The Space Shuttle is a part of the national Space Transportation System, or STS. The Shuttle flight vehicle itself has several major elements, with the Orbiter being the most visible. The Space Shuttle Main Engines (SSME) are a separate Shuttle element, as are the Solid Rocket Boosters (SRB) and the External Tank (the ET is the only non-reusable element of the Shuttle system). While the Shuttle is the major STS component, the European-developed Spacelab, the Inertial Upper Stage (IUS - developed by the USAF), other upper stages, flight crew and ground support equipment, and the East and West Coast launch sites at Kennedy Space Center (KSC) and Vandenberg AFB, respectively, are also essential in the STS. Not an element of the Shuttle, but nevertheless an extremely important ground component for Air Force and DOD use of the STS, is the Consolidated Space Operations Center, or CSOC, planned near Colorado Springs.

Shuttle development, or DDT&E, included production of an initial test Orbiter, OV101, or "Enterprise." This vehicle was used primarily for the Approach and Landing Tests conducted during 1977, in which the Orbiter was released in flight from its carrier aircraft and was flown to a dead-stick landing. During 1978 and 1979, broad development efforts were also bearing fruit as the SSMEs, ETs, and SRBs were being tested and qualified for flight; Orbiter OV101 "Columbia" was delivered; and ground launch facilities at Kennedy Space Center were being completed.

During this same time, the logistics capabilities needed for Shuttle support during DDT&E were being positioned. However, the logistics support for development was logically different than that which would have to follow it for full-scale operations.

Developmental logistics relied heavily on the fact that the system was still in its infancy, launch rates were low, design work was yet to be done, development contractors were involved in system test and operation, and configurations were expected to continue changing through the successful completion of development. Production was just beginning on the remaining operational vehicles, which gave NASA managers a great deal of latitude in responding to operational support requirements. In some cases, production components were already on hand, along with many subsystems' engineering mortality and test units. This apparent wealth of hardware, coupled with the relative immaturity of the program, led to postponing of much expenditure until everyone would agree on what is needed for Shuttle operational logistics support.

That is not to say that support for DDT&E was inadequate. There has always been a source of hardware, a way to perform the required priority maintenance, and some method to move required supplies and equipment. Further, substantial sums were spent for spares specifically for the DDT&E phase and baseline methodology had been set up for most of the logistics disciplines. Even more important for the long run, efforts were begun during DDT&E to define and start acquiring the hardware, data, maintenance and transportation capabilities, and support systems that would be needed for operations.

### STS Operations

It is pertinent here to briefly describe STS operations. The STS will be launched, flown on missions of various lengths and descriptions, recovered, and processed for re-launch at a greatly increasing rate. By 1988 it is planned that this will be occurring 24 times per year: 18 each year from KSC and 6 each year from Vandenberg AFB, using a fleet of four Orbiters. This rapid pace of turnaround, with the much larger quantity of hardware needed for support, means that logistics support will have to be nearly automatic. There will be little time and few spare people to perform the kind of hand-massaging of requirements and hardware availability that has typified developmental stages.

Here, then, is the origin of the logistics challenges; but now it is in development that the big decisions for operations must be made. The very success of the logistics concept used in development has tended to delay that "moment of truth" and has in turn promoted a warm feeling that the spare parts needed in higher volume operations could continue to be located and moved as quickly as they had in DDT&E. The operations environment is going to be considerably different. Contractors who developed the earlier systems may no longer be available or even interested in supporting the equipment. When hardware requirements have not been properly foreseen, the long and often increasing lead times in the program will make new production awkward and especially difficult when support of a failure is necessary.

## Challenges

**Maintenance Support.** On-line or organizational level maintenance on the Shuttle system is done by launch site vehicle processing contractors. So far, off-line maintenance (intermediate and depot-type maintenance) for flight hardware systems has been accomplished primarily by a return to the vendor—either to Rockwell for example as prime Orbiter contractor, to Rocketdyne for the SSME, etc., or to the original equipment manufacturer or subcontractor. For Orbiter and SRB, maintenance and logistics engineering analyses (MEAs and LEAs) and repair level analyses have been started but are not yet complete. Those which have been completed have been of value in identifying the proper range of spares and the support required. When fully accomplished, these analyses will insure that necessary economic trade-offs are considered giving better spares requirements projections.

Preliminary repair level analyses (for development) have supported the return of most flight hardware to the vendor for repair. For an extended operations period, vendor repair might be an expensive alternative. Vendor repair will entail longer turnaround (in-transit) time for reparable and will add another level of contractor overhead. This is offset by vendor availability of test and check-out equipment, specialized fixtures, data and repair procedures, and already trained repair and support manpower. In fact, NASA has not yet procured much of the data needed for non-vendor repair of flight hardware. In some cases, flight equipment is so complex or unique that the vendor has a virtual lock on the capability to do extensive repair. Operationally oriented repair level analyses should be performed for each Shuttle element in the near term, with objective assessments to ensure the analyses accurately consider all capabilities (actual and potential) versus those of the vendors. Realities of the market may in fact force the development of a new intermediate or even a depot capability. Also, we expect Air Force and other DOD service depot repair facilities to become more and more attractive as the original Shuttle equipment ages and original repair sources are no longer available.

Vendor repair commitments were secured through the end of the development period several years ago, and the ongoing production program generally guaranteed availability of needed repair parts. A priority action now is to establish repair commitments for the early operations period, with repair parts identified and stored ahead of the actual requirement. Maintenance capability—primarily repair turnaround time—must support and be consistent with the assumptions underlying the procurement of major spares.

**Sources of Hardware Support.** For aircraft programs, provisioned spares and the maintenance program are considered the main sources of hardware support. For the Shuttle program, production and test assets have been a major source of logistics hardware as well. Some Shuttle elements continue in production or major refurbishment throughout the entire program (ET and SRB). For these systems, continued use of production assets has been accepted as an effective means of providing hardware support with a lower overall expenditure. However, those systems, for which production has a finite (and relatively early) completion date, such as the Orbiter and SSME, are today at the point of needing actual hardware spares in place rather than depending on production.

To use Orbiter as an example, there have been some \$50 million in Orbiter development spares procured; and, of this, over \$30 million worth will be available for carry-over into operations. In addition, about \$330 million is expected to be spent through 1985 on initial lay-in of line replaceable units (LRUs) for operations. Lead times for hardware are already long and are increasing (typical complex avionics LRU lead times are 24-30 months and orbital maneuvering system engines 40-48 months). As a result, proper phasing of spares procurements is important, so the spare hardware will be on hand by the predicted need date.

If hardware is not available, cannibalization will probably be the consequence. At its best, cannibalization is an undesirable partial disassembly of an operationally capable Orbiter for a short period while a priority launch is supported and the broken component repaired. At its worst, cannibalization puts an extremely expensive system out of commission for an extended period.

**Credibility of Requirements.** As long as system configuration is changing, credibility of computed spares requirements will be suspect. NASA Shuttle projects use several systems for estimating spares requirements, depending on the nature of the hardware and stage of the program. Launch site GSE spares requirements for all practical purposes are determined and replenished on the basis of actual usage. Configuration at the launch site is relatively stable, and there is little question that quantities and dollars projected are in an accurate range. The Orbiter project uses a spares requirements model based on the Poisson exponential distribution which calculates that LRU requirements reach desired probability of sufficiency (POS) on an individual item basis. A POS of 95% has been the stated goal for direct mission support Shuttle hardware. ET and SRB spares requirements are also based on a similar Poisson-type calculation. In addition, the Orbiter model has an optimizing capability using marginal analysis techniques. Since dollars for spares are limited, marginal analysis provides computed data showing the best sequence of spares purchase in terms of incremental improvement in overall system POS per dollar spent. NASA believes that this raw data has to be supplemented and results adjusted, using proper engineering judgment, so that the rote predictability of the model will not inadvertently cause illogical procurements. On the other hand, the SSME project and its contractor use a sparing technique which halves the expected meantimes between removal (MTBR), based on observed engine component failures and removals during test and mission operations, and uses the result to calculate the spares quantity required.

All of these techniques have both drawbacks and advantages, but it has become clear that the degree of accuracy of the resulting spares requirements can be based as much on the quality of the input data (raw failure and use data, turnaround times, costs, etc.) as on the absolute real life veracity of the model. Consequently, a major program challenge in the next several years will be to develop and implement systems that feed back real operations and maintenance data for use in calculating and verifying requirements. Such systems will have to reflect, not only failure and removal events, but also the operating or exposure time experienced by the equipment between events. While expensive to devise and operate, these feedback loops will almost certainly provide a net savings to the

program. Further, the implementation of a multi-user Shuttle inventory management system for full support of both the KSC and Vandenberg launch sites will be critical in ensuring that supply issue and demand history is maintained across the entire operational program and the correct inputs are generated for replenishment procurements. Tighter control of the repair cycle will also be a valuable spinoff benefit because with limited assets in the program, intermediate and depot repair turnaround time must be reduced to a minimum and asset location known at all times.

*Limited Life Hardware.* There are really two sides to this particular challenge. One is fairly well understood, and the other may have greater impact than yet appreciated.

First, some of the equipment which was designed for use on the Shuttle has not yet been qualified for the total number of missions, hours, cycles, etc., that were the original design specification. Examples of such components are the wing leading edge, hydraulic power units, and power cells for the Orbiter, and the SSME turbopumps and nozzles. These components have a time change requirement to ensure that they are changed out ahead of a possibly critical failure. Additional work and testing, and possibly further development, will be needed for these components to realize their originally intended design lives. However, these hardware characteristics are already covered in spares projections because they are known and accepted conditions.

The other side of this concern may present some real resource challenges to the STS Operations Program. It has taken a long time to achieve the present Shuttle capability. Much of the program hardware which exists today is fairly old or well into its useful life, including components that have already been produced for use in subsequent production vehicles. Again, the nature of development period support has been to use whatever hardware is already in the system as opposed to procuring additional spares. This has been a cost-effective approach for the short run. However, Shuttle equipment is often operated for more hours in a given process or cycle than was predicted in the design phase. In addition, when components are shifted from end item to end item in order to fill the holes left by failures or other asset requirements, the operating hours on a given piece of equipment can mount very quickly. A predictable consequence is that equipment will reach the end of its expected life sooner than had been originally calculated based on mission frequency or predicted cycles. It appears that a significant quantity of Shuttle hardware could require replacement during the life of the program. This is likely to occur at a time when many of the original production vendors will no longer be producing and may not have or desire the capability to retool or restart their production. In fact, even the technology of the existing design may be obsolete. This concern may be alleviated to some extent by judicious recertification techniques and analytical condition inspections which could allow extension of life limits. It seems unlikely that the entire program can be supported with existing vendors and hardware design. A major challenge for the eighties will be timely recognition of items or systems which can only be supported through changes in vendors and/or hardware design.

*Integration of Management/Support for Two Launch Sites.* The difficulty of operating two somewhat different launch sites has been accepted as a major challenge to both NASA and the Air Force. Actual resolution of the potential problem involves primarily the establishment of a data management system which allows practically instantaneous communication of a very high level of detail. This system must cover configuration, engineering data, procedures, spares location and availability, status of maintenance actions and modifications, problem reporting and corrective action, operating times, and numerous other features. The goal is to be able to launch the Shuttle at one launch site and efficiently recover and process it at the other. In addition, the full impact of the need for full configuration commonality will become apparent as functionally similar systems and items are found to have become dissimilar logistically. That is, later procurements and design upgrades result in different internal components which are the same in form, fit, and function, but still not the same.

From the standpoint of hardware support for two launch sites, the range and depth of flight spares to be stocked at Vandenberg itself has yet to be addressed specifically. Most of the hardware requirements projections have considered the Shuttle mission model as a single homogeneous entity. In fact it will make a difference if a limited number of spare assets intended to cover missions from two launch sites are not properly spread between the two. The capability to immediately support a vehicle component failure, particularly in a countdown, will be as critical at Vandenberg as at KSC.

*Competition for Resources.* Finally, a major problem in any complex program is the competition for scarce resources among the various disciplines which comprise the system and its support. This will be particularly so with the Space Shuttle. Because of its complexity, it will remain an expensive system to maintain and operate. The cost per flight for the Shuttle will have to be held to its lowest realistic level, because of the competitive pressures of other launch vehicle capabilities and the economic realities of payload customer return on investment. Logistics support will comprise a substantial portion of the cost per flight. Unless properly and fully justified when costs are unavoidable, logistics may even be seen incorrectly as a discretionary cost.

In summary, the technical challenges of developing the STS have been enormous; and they are being successfully overcome through the dedicated work of managers, engineers, and technicians both in government and industry. Effective logistics support for the Shuttle must stand the tests of competition with continued development and upgrades; with production of a larger fleet; with yet to be initiated new programs; and with the absolute yardstick of cost per flight criteria. This makes the credibility of logistics requirements even more important. It emphasizes the necessity to pinpoint and minimize costs for limited life hardware. It demands that reliable sources of hardware be established and maintained. It also makes selection of the most efficient maintenance level, locations and capabilities absolutely mandatory. In fact, the competition for scarce resources is what logistics support of the Shuttle in the eighties is going to be all about: Lowest cost support to maintain a superlative space system in a mission capable condition.

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## Liquid Hydrogen—Fuel of the Future

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Crew Protection Branch

School of Aerospace Medicine

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### News Item

*"A program for the development of a baseline liquid-hydrogen fueled vehicle and a liquid-hydrogen-refueling system was completed at the Los Alamos National Laboratory on September 30, 1981. This program involved the cooperative efforts of the Laboratory (funded by the U.S. Department of Energy), the Deutsche Forschungs-und Versuchsanstalt für Luft-und Raumfahrt (DFVLR) of the Federal Republic of Germany, and the State of New Mexico through the New Mexico Energy Institute (NMEI). The results of the program provide a reference point from which future progress and improvements in liquid-hydrogen on-board storage and refueling capabilities may be measured."*

Los Alamos Scientific Laboratory  
Los Alamos, New Mexico 87545

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### The Setting

July 4th, in the year 2050, routinely witnessed the solar scaling of the Amargosa range to initiate yet another beautiful morning for a national holiday. As sunlight crept over the summit, and down the Western slopes from between the spikes of the Funeral and Black Mountains, a small kangaroo rat moved from the shadow of a jagged peak to the warmth of the day's first sunshine. Ironically, this mammalian marvel of adaptive physiology, equipped with a renal system to conserve water in a harshly horned toad hot, lizard dry environment, stood momentarily in a barely discernible fossilized footprint of a prehistoric antelope that perished, perhaps by its own biological ineptitude, centuries before the life threatening dominion of Homo sapiens.

Using the first light of day to search for a morsel with calories to counter the cool of a mountain night, the eyes of this small rodent looked also at times to the distant Death Valley below—ever alert for a potential predator.

Basined from the Pacific by the Western Panamint Range, Death Valley with some 500 square miles below sea level was deeply positioned in Inyo County, California. Removed from National Monument status some twenty years earlier, this driest, hottest, and lowest continental geography was now the site of Valle de La Vida Air Force Base.

The name, Life Valley AFB (LVAFB), was dichotomously chosen in honor of a Hispanic American, Major Primo de La Vida, killed in the near space intercept of a Russian nuclear satellite some years earlier, and also for the free life sustaining mission of this futuristic center of Air Force logistics. Even from its conception, the theme of Life Valley AFB, to provide an *enviromical*\* center of hydrogen fuel research and logistics to support an energy self-sufficient airlift and defense force, was superimposed on carefully engineered plans to maintain the natural ecosystems of the living desert.

\*Enviromical: Creative, inventive, free enterprise products and services which stimulate the economy with the least harmful environmental effect on the healthy consuming citizen.

Away from heavily populated areas, yet central to existing key Air Force facilities (such as the Space Flight Test Center at Edwards and the Space Launch Center at Vandenberg), Life Valley was ideally situated for solar aerodynamal, geothermal, photovoltaical, and nucleonical development.

Actually, once the "Hindenburg Syndrome" had been overcome (the fear that hydrogen always leads to an explosion, similar to the phobia about steam automobiles in the early 1900's), this mecca for H<sub>2</sub> bloomed with power for all. Some fifteen-hundred family units each had 125m<sup>2</sup> solar collectors and wind turbines with 35m<sup>2</sup> wind intercepting surface areas. Maintenance and operation of home units were the responsibility of the occupants. During optimal operation periods, they provided a large net gain for the base power system, contributing to the base mission to produce liquid hydrogen for operations!

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***"Hydrogen is an inexhaustible, non-polluting energy source, can be stored and transported the same as gasoline in liquid form, and has a calorific value 2.5 times that of gasoline."***

Professor Tokio Ota,  
Yokohama National Univ

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### Reflection

Life Valley development did not have the potential to provide all resources; but beyond the dependence on world oil supplies, there was a great colonial spirit reborn in the initiation of a new energy stratagem for space research, laser missile intercept, polar shuttle launch site operations, high altitude reconnaissance, airlift, and now even ground vehicular locomotion from semi-truck to forklift. Additionally inspirational, it reduced requirements for, and the risk of accident from, off-shore or tanker vulnerable oil spills, and perhaps even more importantly, began to stem (or leaf) the rising concentration of CO<sub>2</sub> in the Earth's atmosphere.<sup>2</sup>

In 2050 intelligent young scientists flocked to the Air Force in pursuit of positions to ensure the defense and environmental security of their country! All went to work with the same inventive spirit that drilled the first oil well, designed the first carburetor, or fabricated the first electric starter (ironically, petroleum addiction had begun when hand-cranking was eliminated as "ladies and gentlemen" kindled the spark that ignited the movement toward internal combustion locomotion which replaced the successful electric autos of the early 1900s). With the same hopeful and positive inventive spirit, they determined to resolve the demography of environmental degradation (Figure 1) with the power of scientific, nationalistic, and biologic evolutionary purpose.

Actually thousands of people and tons of diesel fuel were used to establish the basic plumbing needed before LVAFB could spring forth. A 150-mile pipeline for filtered 40% desalinated sea water was constructed from Carpinteria, California, to LFAFB. About 40 miles of this system carried sea water from Carpinteria to near Gorman, where a more extensive system included underground return gaseous hydrogen lines linking LVAFB with Vandenberg, Palmdale International (commercial hydrogen aircraft), and Edwards AFB (Figure 2). A separate hydrogen gas-only line connected Beale AFB with the Life Valley fuel logistics center. Clean sea water, after tidal energy filtration treatment in Carpinteria, with enough NACL remaining to favor electrolyte disassociation, was thus piped from Carpinteria to LVAFB.\* The desalinization plant at Carpinteria also could at times provide completely desalinated water for agricultural uses in the desert.

This essentially unlimited water supply (it was a gravity feed system through much of the distance) provided LFAFB a virtually unlimited supply of water without violating riparian rights of adjacent, arid landowners.

\*The energy for this conversion and pumping was generated by oceanic thermal gradients.



Figure 1: Copyright© 1975 the Chicago Sun-Times.

***"One hypothesis that all three airplane manufacturers [Boeing, McDonnell Douglas, Lockheed] share is that for aircraft use, fossil fuels will eventually be replaced by synthetic fuels and that the hypersonics and other jets will be powered by liquid hydrogen. Nuclear power plants have also been envisioned by Boeing for at least one airplane design."***

Western's World, Jan/Feb 82

The water was constantly converted to hydrogen and oxygen gases by a variety of systems. Solar energy was used during daylight hours for photolytic processes of conversion.

When the afternoon winds blew, electrolytic conversion was accomplished by electricity from aerodynamal turbines. At night, hot-dry-rock geothermal and fusion nuclear energy kept the process active so that there was always a supply of hydrogen in the pipeline system.

***"Public and private energy interests will choose to support or ignore Hydrogen on a largely economic basis. Economic calculations increasingly must include international and internalized social costs, environmental protection costs, and health effects, which tend to be determined by public policy decisions rather than market or corporate policy."***

Kenneth E. Cox,

Hydrogen: Its Technology and Implications (Volume IV).

At Edwards, Vandenberg, and Beale Air Force Bases, and China Lake Naval Weapons Center, the gaseous hydrogen was removed from the pipeline and used directly, or liquified as a fuel for space or air vehicles. Many ground vehicles also used liquid H<sub>2</sub>; however, it was evident that many hybrid systems had been born before the last spasms of the petroleum era. Gasoline, diesel, electric, methane, butane, and even osmotic systems still abounded.

The logistics of part supply for so many hybrid systems was extremely complex and an item of contention for many logisticians who were anxious to press on to design and convert all vehicles to the more universal use of this most abundant element in the universe. (Hydrogen is estimated to comprise 75% of the mass of the universe and 90% of all atoms.)<sup>3</sup>

## Conclusion

Granted—such an energy program involves great and complex tasks which *could* bankrupt our system. On the other hand, or in this instance the other foot, ours are determinedly, seemingly transfixed, to accelerator pedals which only take us farther down the deeply rutted roads of the petroleum era. In the final analysis, the essentially important commodity is human life. Unless far-thinking people in the twenty-first century continue and advance far-space research, Homo sapiens will eventually collectively perish in their own wastes, wars, or wishful thinkings, on or within the near-space of Earth.

Long before such a demise, our kind must seed other planets or moons within the Solar System, with microbes to produce oxygen which, eons in the future, will generate an Earth-like atmosphere. The scientist who has accomplished primordial thinking in this realm also is a codiscoverer of DNA.<sup>4</sup>

The flip side of extinction is continuation—from here to *alternity*. Hydrogen is the ultimate fuel of the future; we should get more extensively into its technology as soon as possible.

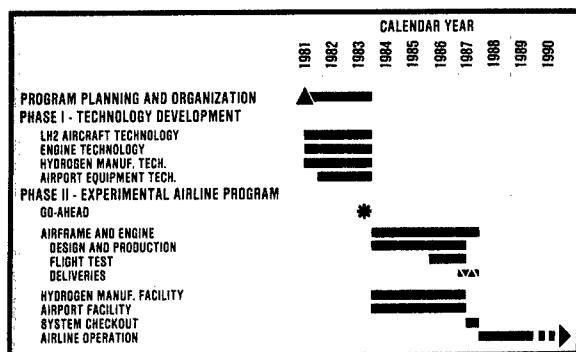


Figure 2: Schedule for the Development of LH<sub>2</sub>-Fueled Aircraft.

### Epilogue

"Hydrogen is an excellent fuel because of (1) the widespread availability of water, its most common source, (2) the rapid recycling from hydrogen to water (regenerating its source quickly), (3) the resulting cleaner environment (almost no pollution caused from its use), (4) the potentially high efficiency in almost every suggested use, and (5) the compatibility with nearly every energy application, such as the internal combustion engine, and every energy source, such as solar. Hydrogen could become the fuel of the future given (1) an incentive to change from the present hydrocarbon fuel, (2) an energy source to produce the hydrogen, (3) an engine to run on hydrogen, and (4) an on-board hydrogen storage system. The on-board hydrogen storage system is discussed here.

Hydrogen has a high gravimetric but a low volumetric heating value; consequently, hydrogen provides nearly three times the chemical energy of gasoline by weight, but only about 25% of the energy of gasoline by volume. Thus, a larger volume fuel tank is required for hydrogen than for gasoline, although the weight of the hydrogen is considerably less than gasoline for an equivalent energy storage. This hydrogen storage problem is being solved in various ways. Hydrogen may be stored on-board a vehicle as a compressed gas, metallic hydride, cryogenic liquid<sup>[1]</sup>, or in a combination of these forms. Those projects involving the use of liquid hydrogen storage are described in this report.

Liquid hydrogen storage is now the only form that can compete with gasoline storage on the basis of weight and vehicle range; however, a large-volume, well-insulated storage container is required because liquid hydrogen is a cryogen of low density. The problems to be overcome for liquid hydrogen use are (1) its volume requirement, (2) its extreme cold, (3) its high volatility, and (4) the additional energy (hence, expense) for its liquefaction. This raises questions of safety and economics. If these questions are resolved, the use of liquid hydrogen for on-board fuel storage for the general public will then depend on successful demonstrations. For fleet operations (buses, trucks, taxis, trains, etc.) the safe use of liquid hydrogen is possible now because the transportation, handling, and storage of bulk quantities of liquid hydrogen for use anywhere within the continental United States has been demonstrated with an excellent safety record. The first use of hydrogen in the U.S. transportation system is likely to be as a commercial aircraft fuel where storage as a liquid provides a considerable weight advantage over present fuels. In fact, an intercontinental demonstration project of a liquid hydrogen fueled cargo aircraft is now in the planning stage<sup>[2]</sup>."

W. F. Stewart, "Liquid Hydrogen As an Automotive Fuel."

**"The use of solar energy to produce liquid hydrogen from seawater is expected to bring about a hydrogen economy...."**

Professor Tokio Ota,  
Yokohama National Univ

### Some Advantages of Hydrogen Logistics:<sup>5</sup>

1. Hydrogen is enviromical (after the original investment) because it saves other fuels for more specific purposes; and when used, it provides no CO<sub>2</sub> pollution.
2. Hydrogen serves as an intermediate energy storage medium.
- \*3. The capricious nature of hydrogen development and the problems of capitalization and eventual commercialization will stimulate free enterprise in much the same way as did the transition from the horse and buggy of 1900.
4. Hydrogen is the propellant of choice for nuclear rockets. Hydrogen heated to high temperature and pressure in a space-born reactor is ejected at high velocity for propulsion.
5. Liquid hydrogen is increasingly used in bubble chambers for photographing paths of subnuclear particles (quarks).
6. Transportation of electricity over long distances is less efficient than hydrogen gas transmission by pipeline and environmentally less desirable.
7. Hydrogen is a low density, high heat fuel and should reduce aircraft noise. Aircraft are lighter and fly higher from steeper ascents off shorter runways.
8. H<sub>2</sub> can be used in magnetic refrigeration systems with lower electrical requirements.
- \*9. Hydrogen technology is versatile. For example at WPAFB, Ohio, hydrogen vehicles and aircraft were fueled from well-cleaned coal gasification rather than deuterium nuclear electrolytic production.
10. Hydrogen has many other uses in production of ammonia and even conventional petroleum fuels.

\*Opinion of the writer. All others are documentable.

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## The Coming Revolution in Avionic Logistics

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### A Perspective

Since World War II, the capability of avionics has improved dramatically—but the way we design and support avionics has changed very little. It is interesting that, with all of the electronic advances of the past 40 years, we still design discrete subsystems as we did in World War II (radars, displays, navigators, etc.). Each subsystem consists of a number of discrete individual boxes. While the performance range and accuracy of each of these subsystems and boxes have improved considerably, the supportability has generally grown progressively more difficult. Although recent avionic systems such as in the F-16 have improved supportability, the long-term trend for supportability is nonetheless expected to continue downward. True, electronic devices are becoming more reliable. However, with a corresponding reduction in device size, the device reliability increases will likely be offset by designing more and more capability into each box. Logistically, this equates to more and more complexity in each box. This is the same trend that has persisted since WWII. The effects of this development trend on logistics are all too evident and have often received national attention. Unless new design and supportability approaches are implemented, the availability, supportability, and affordability of avionics will continue to adversely affect our defense posture.

### Promise of the Future

Fortunately, a number of advanced technologies are now becoming available that can reverse this projected negative trend. These technologies must be applied in concert and in a revolutionary manner, but the payoffs can radically change the USAF logistics posture. Instead of being faced with the simplicity or complexity choices of today, we will be able to implement complex functions in simple standard hardware. Instead of selecting between quantity and quality, we will be able to build large quantities of standard high quality modules. Undesirable choices will not have to be made.

Current line replaceable units (LRUs) will disappear in favor of on-airplane replaceable modules housed in integrated module racks that remain on the airplane. The avionic spares crib will contain a small number of multiple-use standard modules instead of a large number of diverse electronic SRU and LRU types. Avionic functions will self-test before, during, and after flight to determine correct operation and, in critical cases, will heal themselves by substitution of on-line, hot spares. Failures will be automatically isolated to a single, on-aircraft replaceable electronic module, thereby eliminating the need for most of the Avionic Intermediate Shop (AIS). Along with these changes, the cadre of avionic and test equipment technicians needed to support the aircraft will be greatly reduced both in numbers and skill levels.

These sweeping avionic logistics changes will also extend to the depot level. LRU maintenance will disappear and many of the standard modules used in the avionics will be low-cost, high-reliability, throwaway items. Consequently, an avionic depot repair facility for these modules will not be required. Since the modules will be transparent to technology and will be purchased to a form, fit, and function interface standard, replacement modules will be built with the then current technology rather than with that of the original buy, thus keeping pace with advancing technology. As a result, the present problems of providing SRU repair parts in a constantly changing technology environment will disappear.

### Solution Near-Term and Broad-Based

The promises of the future for improved logistics are not utopian. They are achievable with current technology. Three of the key advances that can enable new avionic designs to obtain the desired logistic benefits are:

1. Low-Cost, Single-Chip Digital Processors
2. High-Speed, Single-Chip Digital Multiplex Terminals
3. Single-Chip VLSI/VHSIC Technology
  - Computer Memories
  - Standard Interface Test Chips
  - Standard Functions

The key element of these technologies is size reduction. As size shrinks, bringing reductions in cooling and less requirements for power, it becomes evident that the opportunities for implementation of common hardware can become a reality. For example, the size of a MIL-STD-1553 digital multiplex terminal has shrunk from three 5" x 7" electronic cards in 1976 to a single 5" x 7" card today and will shrink to a single 4" x 5" card by 1984. The next step will reduce the size of such a terminal to a pair of VLSI integrated circuit chips. Given a standard module package and standard casings and fittings, all avionic equipment could then utilize the same multiplex terminal hardware.

Most important, however, is the application of this technology on a broad front. This will result in meeting the decisive needs and promises of future logistics rather than making only small incremental improvements. The areas to be addressed in concert to achieve the decisive edge are identified as follows:

- Standard Modules
- Advanced Architecture and Multiplex
- Extensive On-Board Self-Test
- Integrated Avionic Racks

Independent applications of all of these technologies in the normal manner cannot produce the order-of-magnitude logistics gains that are achievable through a concerted application.

## Standard Modules

Analysis of various types of avionic systems has shown that identical types of functions are performed in many different systems and in different parts of the same systems. Figure 1 shows how this commonality of functions is shared between a group of five aircraft systems. An unusual combination of systems has been selected to dramatize the commonality of functions even among diverse systems. If the more conventional avionic systems are added to the list, the same sharing of function types is also observed.

COMMON FUNCTIONS AVIONIC SUBSYSTEMS	Computing	Analog/Digital Interface	Digital/Analog Interface	Digital/Analog Control	Discrete Interface	Frequency-Digital Interface	Mass Memory	Power Supply	Serial Digital Multiplex
FLIGHT CONTROL	✓	✓	—	✓	—	—	✓	✓	✓
ENGINE CONTROL	✓	✓	✓	✓	✓	✓	✓	✓	✓
ENVIRONMENTAL CONTROL	✓	✓	✓	✓	✓	—	✓	✓	✓
AIR INLET CONTROL	✓	✓	—	✓	—	—	—	✓	✓
AIR DATA & MOTION SENSORS	✓	✓	—	—	—	—	—	✓	✓

Figure 1: Common Function Types Are Shared by Different Systems.

In today's avionic designs, each of these common functions is performed by a unique hardware design. Typically, different vendors will provide different hardware even though the functions are identical. This situation exists because current designs emphasize LRUs (circa World War II) rather than functions. On the other hand, if standard interfaces and packaging are adopted (as is possible with a unified systems architecture), it becomes practical to design standard functional modules for multi-use applications. These modules, plus unique sensor and effector interface modules, then become the building blocks for a new type of system architecture. Virtually any type of system function can be built from these modules together with suitable software. Because the common module types will be used in many different applications, it will be cost-effective to develop special VLSI circuits and production methods that will permit such modules to be manufactured in large quantities at low cost.

Figure 2 contains a general description of one such module and lists some of the more important features. Such a computer module is currently feasible using the MIL-STD-1750A processor chip set being developed by the F-16 program. Other modules of the family would be of similar construction.

Modules of the type shown in Figure 2 will be physically protected from the flight-line environment to which they will be exposed. For this reason, hermetic sealing will be employed. The modules will become the line replaceable units and therefore must be designed accordingly. Current module or card design approaches will not suffice.

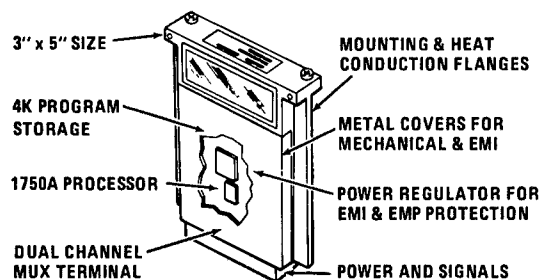


Figure 2: Typical Standard Computer Module.

## Advanced Architecture and Multiplex

A new type of modular architecture will be necessary to utilize standard modules of the types discussed. Multiplex communication will be used between modules and not just between LRUs as in existing designs. This approach will largely eliminate many thousands of mechanical electrical connections that are used in current avionic equipment. It is ironic that, while these connectors facilitate rapid field replacement of defective elements, they also contribute failures that increase the number of maintenance actions. In modern digital equipment, even a momentary break in a connection tends to register as a hard failure. Evidence indicates that connection related problems may be responsible for a large segment of the could-not-duplicate (CND) and re-test-OK (RTOK) problems that (1) tax maintenance resources and (2) tend to repeat in flight and reduce combat effectiveness.

Figure 3 is a block diagram showing an example and benefits of such architecture. This example is an inertial navigator that uses digital multiplex to the module level and is built almost totally from standard modules.

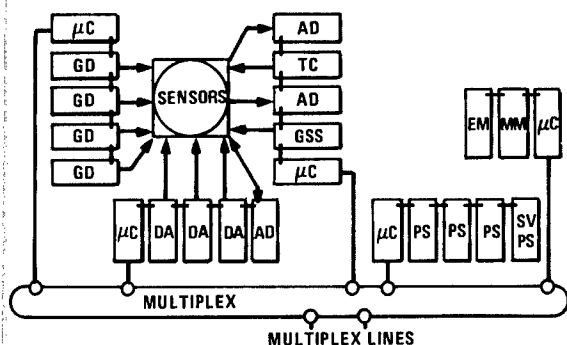
Elements such as those shown in Figure 3 become building blocks in a conventional sense for larger subsystems and systems in much the same way that the standard modules are building blocks for this element. The same standard, digital multiplex communications interface is used at all levels to simplify design and permit necessary data interchange at all levels of the system.

Advanced multiplex networks of the type needed for such applications have already been designed and breadboarded. These networks employ advanced data switching techniques to provide the necessary data transfer rates to handle both high-speed digital and wide-band video type data. The terminals transmit less than one-quarter watt of power and can be constructed entirely with VLSI chip technology. The only remaining step is to reduce the hardware to VLSI integrated circuit chips suitable for use in small, standard modules.

## Extensive On-Board Self-Test

Standard modules with multiplex interface between modules are particularly well adapted to complete, on-line self-test. First, the many thousands of interconnects with conventional avionics are eliminated, which directly reduces the scope of module self-test. Simplified interface equates to simplified, more comprehensive self-test. Second, multiplex lends itself to end-to-end testing with a pulse-by-pulse self-test for 100% confidence. Third, VLSI makes it possible

- 80-90% WIRING AND CONNECTION REDUCTION
- MODULE LEVEL SELF TEST
- STANDARD INTERFACES



**Figure 3: All-Multiplexed Architecture for an Inertial Navigator Using Standard Modules.**

to provide special self-test chips that can be utilized in each standard module.

Since testing is performed during flight, intermittent failures are detected and isolated in the environment in which they occur. Most CNDs and RTOKs are eliminated. In addition, the built-in test capability of the modules and the advanced multiplexed communications make it practical to provide on-line, hot spares for many critical functions. Such spares provisions not only permit systems to heal themselves after failures, but may also allow maintenance deferral. If a system has corrected a failure, the urgency to replace failed modules between missions is reduced. Finally, the test capabilities provide the maintenance personnel with fully automatic identification and location of failures, thereby enabling rapid line replacement of failed modules. Such failure information may be either data-linked ahead from the airplane while in flight or read out by maintenance personnel via a portable reader capable of transmitting failure data stored at a central location on the aircraft.

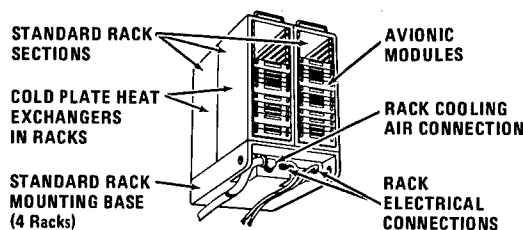
### Integrated Avionic Racks

Direct module replacement at the airplane level will be a major logistic benefit of the new technology avionics. To achieve this goal, an integrated rack packaging will be used in place of existing LRUs. Racks similar to that shown in Figure 4 will permit ready access to individual modules. Many of these common integrated racks will be used throughout the airplane and can be larger or smaller depending on application. The rack sections will be separately removable from the aircraft to permit back-plane repairs or modifications. Compared to current avionics, these repairs should be very infrequent, since all racks will utilize back-plane wiring that is reduced by approximately two orders of magnitude from that of current avionics.

Individual modules will be enclosed in sealed metal cases to provide complete mechanical and EMI/EMP protection. These rugged, sealed modules will permit flight-line replacement. All modules will be cooled by conduction to cold plates in the integrated racks. Either forced air or liquid cooled versions of the rack may be used.

### Benefits and Problems

The overall impact of the new avionics technology will have widespread effects in many areas of operations,



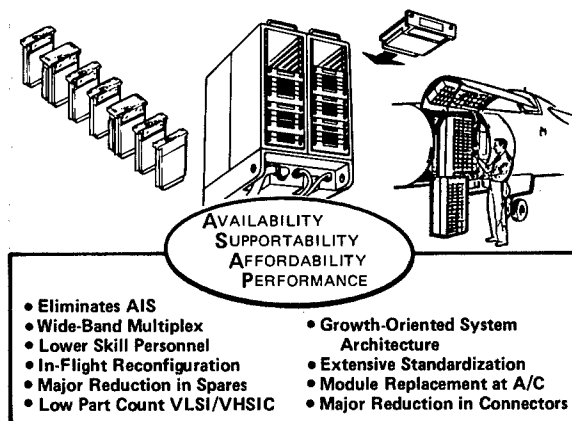
**Figure 4: Typical Integrated Avionic Rack.**

logistics, and equipment acquisition. Figure 5 provides a summary of the resulting avionic hardware, installation, and the availability, supportability, affordability, and performance (ASAP) implications of the changes.

While these avionic benefits will largely solve most of the problems being experienced today and probably make an affordable Air Force possible in the future, there is no assurance that this will occur. Although large, decisive improvements are critical for survival and victory, they are culturally difficult to implement. A revolutionary application of new technology will require a revolutionary change in both the USAF and industry.

Procurement of avionic systems and spares will undergo a dramatic change. Industry product lines and alignments will change. USAF procurement policies will be altered. Standard modules will be procured directly by the military from module sources and will be provided as GFE to avionic vendors. Avionic systems developers will find themselves creating special sensor and effector modules and function-unique software to be used with standard modules common to many other uses. Because most functions of the Avionic Intermediate Shop will disappear, the large organizations now associated with this function will be greatly reduced. With large numbers of throwaway modules, the depot repair facilities and organizations will shrink, or the function will revert to the original manufacturer.

These changes can provide far more Air Force fighting power per dollar. The task is technically achievable. The challenge is to break free of the comfortable post World War II path of avionic design and support. Instead of incremental applications of advanced technologies with incrementally small improvements, a revolutionary and concerted technology application to gain a decisive advantage should be made. The future of Air Force Logistics is in the balance.



**Figure 5: Across-the-Board Benefits.**

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## Logistics and Advanced Technology

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### Abstract

*Selected improvements for logistics operations are identified in the areas of automatic testing, forward-area transportation, and computerized communications infrastructure. Various concepts associated with these logistics activities are considered, and techniques are presented that can facilitate implementing the suggested changes. An overview is also provided of advanced technological devices that could be incorporated in these proposed improvements and utilized in other applications within the logistics purview.*

### Introduction

The logistics community, with much interest, is examining new and better ways to perform logistical functions by the use of emerging technological devices and procedures. Endemic to these considerations is the necessity to perform logistical activities with as much proficiency and imagination as possible in view of the rapidly changing demands placed upon logistical operations. The theaters of operation vary from large central complexes in totally controlled environments to field support in distant lands under potentially hostile and/or primitive conditions. In order to meet this broad and demanding set of requirements, it is patently necessary that the logistical procedures and techniques use a technological base that is commensurate with the sophistication of the materials and activities being supported by the logistical function.

In this paper we will first review selected concepts of logistics support in avionics testing. Communication infrastructures will then be considered as a part of the overall problem of knowledge and material exchange. Attention will then be focused on generic advances in technology that may find application in logistics activities. The paper will conclude with a brief summary of the developing areas of computer technology that may be advantageously appropriated by the Logistics Command in the near to intermediate future.

### Logistics Support for Avionics

#### Automated Test Equipment Considerations

As military aircraft have evolved into increasingly complex systems, there has been a similar trend toward greater complexity in the related areas of check-out, testing, diagnosing/replacing of defective components, and refurbishing of specialized support subsystems. This movement toward greater complexity in the logistics function has been accompanied by escalating costs for the advanced technology support systems and infrastructure. At the same time, there has been a decrease in the availability of volunteer enlistees who are academically qualified for training in advanced technology. This shortfall of trainable personnel has led to logistics training programs that are based on the "smart machine/dumb operator" concept, which has

been shown to have several undesirable consequences (1:22-26, 45-51). Let us consider the implications of the evolving and highly sophisticated test equipment that is now used in virtually all maintenance programs for advanced military aircraft.

The full impact of this proliferation of complex automated test equipment (ATE) for military aircraft subsystems was dramatically illustrated during the Red Flag maneuvers held at Nellis AFB in June 1980. In order to demonstrate the feasibility of supporting a squadron of F-15s in a forward area, an F-15 Avionics Intermediate Shop (AIS) unit along with its supporting Precision Measurements Equipment Laboratory (PMEL) was airlifted from Holloman AFB, New Mexico, to Nellis AFB, Nevada. The AIS/PMEL unit was operable within 72 hours (with aid from Nellis AFB) to correct "this-time-only" type teething problems). Although this relocation demonstration was impressive, it must be noted that the AIS/PMEL unit, along with the associated shelters, power generation equipment, and general support items, constituted such an extensive shipment that four C-141 transport aircraft were required to accomplish the airlift! This transportation requirement presents an extreme burden on the Air Force Military Airlift Command's wartime airlift capability for all but very limited conflicts.

From this single illustration of a routine logistics function emerges a clear challenge to develop more compact and efficient automatic test equipment systems. Goals for the near, immediate, and far terms can be suggested to address some of these problems:

(1) *Near Term.* Develop an AIS system that can be airlifted by a single, long-range transport aircraft, one that is capable of supporting operations in forward areas.

(2) *Intermediate Term.* Examine the total AIS requirements for all aircraft subsystems (e.g., communications, navigation, radar, EW (ESM/ECM), IFF, target acquisition/tracking/designation, bomb delivery/command/fuzing) and then define a Total System Intermediate Shop (TOSIS) concept. The TOSIS approach can be best introduced concurrent with the development of a new aircraft, while the prime contractor still has the opportunity to impose TOSIS-compatible requirements on subsystem developers.

The advantages of a TOSIS approach include at least the following items: (1) sharing of common equipment (computers, terminals, test jigs, test equipment, software organization, etc.), which leads to a significant reduction in total weight and volume of ATE; (2) utilizing more generic equipment that can incorporate microminiaturization and advanced technology components; and (3) reducing significantly the procurement and operating costs of logistics systems as well as the number of items in inventory.

(3) *Far Term.* Assess ATE requirements for all aircraft systems in the inventory and encourage increased parts commonality and modularity in design. The emphasis is placed on developing a suite of Generic

ATE (GATE) systems for all USAF aircraft that can support all levels of maintenance and all electronic/avionics subsystems. Although the full realization of this broader goal will not come for many years, the definition of studies and the generation of requirements for the procurement of future aircraft systems incorporating the GATE concept could begin immediately.

The technical capabilities of these projected logistics systems can be enhanced by adopting several existing and emerging technologies:

- Solid-state components
- Optical circuit elements
- Microprocessor devices
- Communications/computer nets that are user responsive
- Computer-on-chip
- Monolithic microwave integrated circuits (MMIC)
- Very high speed integrated circuits (VHSIC)
- Very large scale integration (VLSI)

The great reliability of all-solid-state electronics, the many-fold reduction in packaging volume achievable with micro devices, and the significant reduction in power consumption of such devices will permit the TOSIS/GATE systems to be packaged very efficiently. Correspondingly, a much less onerous burden will be placed on airlift vehicles to transport such systems to forward areas.

#### Radical Transport Suggestions

An important aspect of the overall logistics function is to provide the means for delivery of personnel and supplies. In the area of delivery there have been fewer innovations over the years than in the weapons and ATE systems themselves. In this subsection, let us consider briefly some selected aspects of the delivery mechanism and hypothesize about innovations that could be introduced.

During World War II, an attempt was made in Europe to drive a wedge through Holland in order to resupply and relieve the 1st British Airborne Division that was holding the bridge at Arnhem. Had the wedge maneuver been successful, the war might have been shortened by a full year. However, radio communications failed, the main ground transport route could not be opened, and air support activity was brought to a standstill because of weather conditions. Although considered, the idea of using the waterways for delivery was not seriously pursued.

Using present technology, it is more feasible today to resupply such forces in similar circumstances; e.g., remotely piloted vehicles (RPVs), designed with low radar-cross-section (RCS) and equipped with compact autopilots, could be used alone or as tugs for cargo gliders (also having low RCS) to deliver essential supplies to an encircled combat group. In addition, high-priority emergency items can be accurately delivered by special-payload shells/missiles that are fired by artillery or are self-propelled and that use air brakes/parachutes for soft landings. Special submersibles can also be utilized to transport key personnel and limited supplies along canals and rivers—even along the bottoms. All of these items represent special-purpose technologically feasible delivery systems which have not been and are not presently used as combat support transport vehicles.

These more exotic means of delivery have not received the attention that their potentially critical value

deserves in comparison with the standard transport aircraft that are used for the vast majority of everyday deliveries. The fact that these radical delivery systems cross traditional service lines should not deter the active development, experimentation, and evaluation of feasibility demonstration prototypes. In fact, the great variety of situations, which exist in the diverse theatres of operation in the current geopolitical environment, dictates that such "radical" transport systems be available when standard delivery means cannot do the job.

The state of existing technology makes such radical delivery systems possible and forces recognition of the need for increased coordination among the services. Such coordination would also promote a greater degree of commonality in standard logistics delivery systems of the three major services.

#### Communications Infrastructure

The literal "lifeline" of a complex military operation is the capability to communicate among the various elements. Indeed, the communications aspect of logistics activities is of paramount importance, since great coordination of movement and a constant knowledge of dynamic status are absolutely essential to insure adequate support activity. Within the field of communications the use of computer systems for data management has come to be considered almost a panacea for all problems involving the retention and acquisition of knowledge. Considerable effort is presently being expended in designing computer systems that can operate in both a linked and an autonomous manner. Let us examine some of these concepts and then postulate how they might be applied to the logistics function.

The basic computer-system configuration that has emerged in the last several years involves a large central processing facility with extensive memory and data banks that can be accessed by remote, intelligent terminals (2:27-39). The prioritized needs of the total set of on-site and remote users will determine how intelligent and how powerful the remote terminals must be in relation to the console terminals co-located with the host facility. Access to the central facility involves both retrieval/refreshing of information resident in the data banks and use of the central processing unit in the large host computer.

The question of user priority must be addressed in defining the hierarchical structure of information processing. Although it is natural and proper to accord highest priority to servicing the needs of front-line users, care must be taken in planning the supervisory control so that lower rated users are not effectively screened from accessing the information network. With regard to the carrying out of the various logistical functions, this networking must be constructed under the directive that the overall logistics support function is a total process rather than merely a concatenation of many isolated activities. Let us now examine these concepts further in selective detail.

The configuring of an information processing network with a "hub" computer and several satellite terminals is well understood at this time. Most universities and industrial development laboratories have had such a network configuration for several years. A key point to be considered in establishing the network is the degree of

distributed processing that is to be done; i.e., to what extent are the remotely located satellite computer terminals allowed access to the host complex for service. In addition, the extent to which the remotely located nodes are permitted to refresh the central data base must also be defined. Finally, proprietary information must be considered in establishing the need for secure data bases with password keys.

There are several immediate applications of these computer system capabilities to the USAF Logistics Command function:

(1) Much benefit can be derived from having complete and up-to-date information on all equipment and parts stored in a central location that can be accessible to all parties with documented needs. This information greatly expedites access to equipment maintenance schedules and to the status of the spare-parts inventory and distribution network. At each nodal point on the computer network, the repair record of a given piece of equipment could be easily ascertained and then a refreshing or an updating of that data be made in real-time to reflect local actions toward the equipment. In addition, the flow of spare parts could be more closely monitored and potential bottlenecks avoided or at least minimized.

(2) The extensive area of systems diagnostics, technical orders (TOs), and hardware/software updates could come under more centralized control. An electronic distribution system for technical diagnostic information is vastly superior to the present method that relies on mailings and the willingness of individuals to take the time to log or "write up" their activities and findings. The instant availability of the latest diagnostic and troubleshooting information is a tremendous asset to field operations that are unduly dependent upon the resident talent, skill, and experience of the personnel at their particular location. Moreover, the savings in time and money of the reduced paper handling would be significant. Hard copies of diagnostic procedures, logic diagrams, and flow charts can always be obtained from local printers tied into the computer network.

(3) A distributed information processing network offers the opportunity to users to participate in interactive learning programs. Instructional sessions in many subjects ranging from computer languages to electronics have been prepared and are available as self-teaching aids. One of the major complaints of the educationally ambitious service personnel at field locations is the lack of on-the-job (OJT) learning opportunities. The distributed information processing network offers an excellent solution to this problem.

(4) The Logistics Command is increasingly desirous of using stand-alone terminals or computers in their analytical activities in addition to processing administrative data. These "personal computers" can be readily tied into the information network that contains other satellite computers and the large time-sharing host processor. The computer power of the network then becomes available to the "isolated" user, which greatly enhances the capability and versatility of the personal computers scattered throughout several facilities.

It has been our intention in this section to be suggestive rather than exhaustive in citing a few direct applications of computer networking concepts to recognized areas of need in the logistics arena. With the advent of geosynchronous communication satellites,

the possibilities for instantaneous worldwide exchange of logistics information can become a reality using an information processing network whose technology exists today.

## Advanced Technological Elements

During the past decade, advances in material sciences have led to smaller and more diversified integrated circuits, hybrid devices, and other forms of active electronic components. These advances have increased the operating speed of integrated electronics while reducing the power required to operate these devices. The reduction in size of both the integrated electronics and the required power supplies has far-reaching effects. Not only are the overall size and weight of a system reduced, but thermal stresses are also diminished as the heat dissipation problem is minimized. Moreover, reliability and maintainability, which help to measure system readiness, are improved. These advances are affecting avionics and the equipment used to test the avionics systems.

The greatest advances in innovative products have been in the area of programmable integrated electronics. Several of the new technologies that have had significant impact in the memory area include the charge coupled device (CCD), dynamic random access memory (DRAM), bubble memory, and electrically erasable programmable read only memory (EEPROM). The EEPROM concept is the same as a programmable read only memory (PROM) except that the EEPROM can be reprogrammed. Although not totally an integrated electronic device, bubble technology has permitted the size of mass disk type storage to be reduced to a single package for insertion onto a printed wiring board.

The use of these advanced products makes it possible to shrink the physical size and power consumption of memory required for system minicomputers, as is illustrated by the current upgrade of the ALR-46, -46A, -69 family of Radar Warning Receivers (RWRs) (3:73-75). The original RWR had 5K words of PROM and 1K of volatile read/write memory located on two 9.6-inch by 6.6-inch circuit card assemblies (CCAs). In the upgraded RWR, the five-card CPU and the two memory CCAs were replaced by a single CCA; and the memory was increased to 24K words of nonvolatile read/write memory (using EEPROM) and to 8K words of volatile read/write memory. These upgrades yielded a throughput increase of over four times. This example of technology insertion illustrates an enhancement in both reliability and maintainability without major impact on the software and without any modifications being made to the group A (aircraft) wiring for the ALR-46, -46A, -69 family of RWRs. Similar upgrades can be achieved in other avionics equipment without altering their basic overall configurations.

Advances in integrated electronics have also been made in programmable logic. In this area the use of programmable array logic (PAL) or field programmable logic array (FPLA) devices makes it possible to replace approximately 20 standard digital dual in-line packages with a single dual in-line package. In addition, newer PROMs provide ever-increasing density while reducing power and physical size.

Major advances are also being made in the single chip or chip-set high-power processors. The new generation of processors can provide, on two or three integrated

circuits, a comparable computing power to that of a DEC PDP series of Data General Nova series minicomputer. This type of processing power has been incorporated into many new and upgraded avionics systems, primarily because of the ease of quickly updating software parameter values, and also because the inclusion of a processor in a system allows self-tests and diagnostics to be run with minimal ground support equipment.

The signal processing and communication areas are also experiencing major changes. Hybrids and VHSIC/VLSI products are reducing physical size by at least an order of magnitude while reducing or, at worst, maintaining power consumption. In signal processing the increase in speed of analog-to-digital/digital-to-analog converters, multipliers, and adders has permitted digitizers and other subsystems to run faster than 200 MHz. These building blocks are used in hardware FFTs, correlators, and digital filters, and improve the overall throughput of the processing system. Some of the new VLSI products contained in a single integrated circuit will perform such diverse functions as signal processing at the antenna feed, target identification processing, sonar signal processing, and phased array antenna control.

Although these innovations have been primarily directed toward onboard aircraft systems, associated ground support equipment can also benefit from the new technologies. In both cases, maintainability increases while logistics support requirements decrease. These same technology advances can be applied to test equipment, which will correspondingly lead to reductions in size and in required logistics support and will also increase reliability and maintainability. The accompanying reduction in power requirements for the test equipment will further reduce weight, operating temperature, and generator power needed to run the equipment, and will make the testing facilities more mobile while curtailing downtime.

In concluding this overview of advanced technological innovations, mention should be made of a different type of device; namely, products associated with commercial point-of-sales markets. In particular, one of these products is the bar code reader, which might be used in military logistics in the following way. If a sticker displaying the serial number were affixed to each piece

of line replaceable unit (LRU) equipment, then a bar code reader could enter this information into the test equipment computer. The computer network to which the test computer is linked would then be able to recall the repair history of the LRU and to display the appropriate portions of the TOs and schematics that are required for service. This computerized system would provide a base of information for identifying needed upgrades of poorly performing equipment, eliminate excessive amounts of paperwork, and enable current updating of the data bank.

## Conclusions

The concepts and technological advances considered in this paper promise higher reliability, improved maintainability, and decreased logistics transportation requirements for avionics equipment and for their associated ground support equipment. These anticipated gains can only be achieved through a coupling of continued research and development activities with a willingness to incorporate these innovative approaches into the total logistical systems process. The range of advanced technology that can be assimilated into the logistical function extends from the smallest chip device to new delivery systems for transporting personnel and supplies into forward-area operations.

The time has arrived for the USAF to act to reverse the trend toward the costly proliferation of many unique ATE systems and to implement a system philosophy that is based on a Total System Intermediate Shop (TOSIS) and a Generic ATE (GATE) support system.

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# CURRENT RESEARCH

## Air Force Logistics Management Center - FY82 Program

Periodically, we, at the Logistics Management Center, contribute to this portion of the Journal. Our last contribution appeared in the Spring 1981 edition. Many of the projects that were in that listing have been completed, and we sincerely hope the Air Force Logistics community is more efficient because of them.

The cooperative efforts outside of the Center have been outstanding. Students and faculty members of Air University and the Air Force Academy provided significant inputs to our projects. Other personnel from MAJCOMs and bases have helped us by providing "real world" data; test-bed sites; survey participants; "sounding boards" for new approaches; and, in several cases, key recommendations on better ways to solve logistics problems.

If you are interested in any of these projects, please contact the project officer. If commercial lines are used, dial Area Code 205, 279-plus the last four digits of the AUTOVON number.

### Current Projects

#### COMPES Automated Load Planning Systems (CALPS)

Objective: (1) Develop an on-line computerized simulation model capable of load planning Air Force mobility equipment/personnel on military cargo aircraft and Civil Reserve Air Fleet (CRAF) aircraft. (2) Develop an automated program for use at base level to plan palletization of cargo using 463L system cargo airlift pallets. The model documentation on the two models will provide a baseline for production of a formal change to the Contingency Operation/Mobility Planning and Execution System (COMPES) Functional Description for development of a standard base-level automated load planning system as a subsystem of COMPES.

(Lt Col Osborne, AFLMC/LGX, AUTOVON 921-3535)

#### Deployable Mobility Execution System (DMES)

Objective: Develop prototype deployable microcomputer system for introducing COMPES and the COMPES Automated Load Planning System (CALPS) into a wartime environment for movement of combat units.

(Capt Cameron, AFLMC/LGX, AUTOVON 921-3535)

#### Computerized Harvest Bare Asset Management Project (CHAMP)

Objective: (1) Develop an automated system which will enhance Air Force capability to provide more accurate and timely Harvest Bare/Eagle execution packages in support of deployment tasking. (2) In conjunction with other functional entities, identify other aspects of Harvest Bare/Eagle which would benefit from information in an automated inventory data base. (3) Develop follow-on automated functional management reporting systems, as required.

(Maj Smith, AFLMC/LGX, AUTOVON 921-3535)

#### COMPES-M Feasibility Analysis Enhancements

Objective: Identify logistics feasibility analysis requirements in support of contingency planning and operation execution. No Air Force standard system exists for feasibility analysis of non-unit related assets such as munitions, rations, TRAP, housekeeping material, POL, etc.

(Maj Leigh, AFLMC/LGX, AUTOVON 921-3535)

#### Ground Petroleum Computations

Objective: Develop and test an automated system that will compute bulk ground fuel requirements for WRM vehicles and equipment more accurately than current methods.

(Maj Smith, AFLMC/LGX, AUTOVON 921-3535)

#### Wartime Automation Requirements for Maintenance

Objective: Determine what automated maintenance management processes are critical to the ability of maintenance organizations to provide ready maintenance forces for contingency and combat operations. Determine the characteristics of the system needed to satisfy these requirements. Includes on-going prototype effort for a deployable engine tracking capability for F-15, F-16, and A-10 aircraft.

(Lt Col Dietsch, AFLMC/LGM, AUTOVON 921-4583)

#### Rivet Ready Maintenance/Supply Interface

Objective: Review repairable processing system with a view towards improving responsiveness. Evaluate current policies, procedures, and problems that hinder responsiveness. Recommend policy and general procedural changes to improve responsiveness in short range, intermediate range, and long range. Determine implications of major policy changes.

(Maj Hughes, AFLMC/LGM, AUTOVON 921-4583)

#### Lifetime Warranted Tool Program

Objective: Investigate the Quality Deficiency Reporting system with respect to hand tools, examine the Federal hand tool specification process, identify problems in hand tool procurement, and conduct a life cycle cost comparison between General Services Administration (GSA) and commercial hand tools. Procure lifetime warranted tools for use by AF maintenance activities to increase productivity and reduce O&M costs.

(Capt Wheeler, AFLMC/LGM, AUTOVON 921-4581)

#### Aircraft Maintenance Workcenter Supervisor Handbook

Objective: Provide each MAJCOM sponsor with an aircraft maintenance workcenter supervisors management handbook which functionally explains the management duties and responsibilities required by regulation. The handbook will provide step-by-step guidance and all references needed to assist supervisors in developing skills necessary for workcenter management. It will be written in the language of the inexperienced supervisor in terms that are clear and easily understood.

(Capt Racher, AFLMC/LGM, AUTOVON 921-4581)

#### Develop a Base-Level Pricing Guide

Objective: Provide base-level contracting personnel with practical guidance on how to negotiate and document reasonable contract prices. The guide will assist personnel who are inexperienced in price and cost analysis to understand and use the detailed procedures contained in applicable contracting directives.

(SMSgt Britain, AFLMC/LGC, AUTOVON 921-4085)

#### Commander's Guide to Air Force Contracting

Objective: Provide commanders with a tool which outlines their roles and responsibilities in a contract environment. This would ensure no degradation in mission capability and readiness because commanders would be involved throughout the entire life cycle of a contract.

(MSgt Chapman, AFLMC/LGC, AUTOVON 921-4085)

#### Air Force Property Loss Reduction Initiative

Objective: Evaluate and propose a marking system for AF property. Project will consist of two phases. Phase I will be the evaluation and recommendation of a simple system to mark AF property with "Property of US Government" or similar marking. Phase II will be the evaluation of a sophisticated identification/marking system to trace specific lost or stolen AF property.

(Lt Hoskins, AFLMC/LGS, AUTOVON 921-4165)

#### Source Data Automation (SDA)/Standard Base Supply System (SBSS) Base Service Store Enhancement

Objective: Test SDA technology through the use of commercially available Point of Service (POS) equipment in the supply complex, specifically in the Base Service Store retail outlets. Provide pilot effort upon which applications of POS equipment within the SBSS can be examined. Evaluate alternative machine-readable symbologies for future use within Air Force retail outlets.

(Maj Orenstein, AFLMC/LGS, AUTOVON 921-4165)

#### Dyna-METRIC

Objective: Determine the capability of the Dyna-METRIC model to relate WRSK support levels to combat capability and integrate this model into the Combat Supplies Management System (CSMS).

(Capt Ogan, AFLMC/LGS, AUTOVON 921-4165)

#### Microcomputer Applications within the Standard Base Supply System

Objective: Identify those processes within the Standard Base Supply System that might be improved with the application of microcomputer technologies. After these processes have been prioritized, analyze the improvements possible from microcomputer applications.

(SMSgt Nichols, AFLMC/LGS, AUTOVON 921-4165)

#### Vehicle Requirements for Incremental Levels of Conflict

Objective: Develop an objective method to accurately determine the vehicle requirements needed to support various stated levels of wartime activity.

(Maj King, AFLMC/LGT, AUTOVON 921-4464)

#### Hazardous Materials Training

Objective: Determine Air Force hazardous materials training needs, modify current policies, and create a hazardous materials information distribution mechanism to keep personnel in the field updated.

(Capt Friedl, AFLMC/LGT, AUTOVON 921-4464)

#### Technology Transfer and Innovation

Objective: Create a framework within which Air Force logisticians can keep abreast of relevant technological advances and promote the use of ideas from both the military and civilian sector. Current efforts are centered on conducting a literature review and performing case study analyses to formulate a structure/theory for technology transfer in logistics.

(Capt Alten, AFLMC/LGY, AUTOVON 921-4524)

#### Computer Graphics in Logistics

Objective: Explore and identify potential benefits of computer graphics technology transfer to logistic functional areas. Prototyping various applications with in-house resources is anticipated.

(Lt Daniels, AFLMC/LGY, AUTOVON 921-4524)

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## Directions in Research and Development for Logistics

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### Introduction

Having participated in the National Security Industrial Association (NSIA) Logistics Research and Development Symposium held in cooperation with the Department of Defense (DOD) in Arlington, Virginia, on March 31 and April 1, 1982, I was impressed with the need to play Paul Revere and get the word out. The program which was chaired by Mr. Richard C. Banta of Westinghouse was relevant and significant to our community. Also, since I had also been requested to author an article on research and development in the defense industry for the *Air Force Journal of Logistics*, I decided it would be beneficial to summarize for the Journal readers some of the events of the NSIA symposium. A brief listing of current logistics R&D projects being accomplished at the Westinghouse Integrated Logistics Support Divisions and the Westinghouse Central Research Laboratories is also included.

I must point out that the symposium was not recorded or transcribed, although several of the speakers did provide me with copies of their prepared texts. These comments will be brief and names are provided as points of contact.

### Keynote Address

Dr. Lawrence J. Korb, Assistant Secretary of Defense, Manpower, Reserve Affairs and Logistics (MRA&L), expressed his pleasure at the number of attendees (approximately 150) representing industry, DOD, and the Services who are involved in logistics R&D. Dr. Korb went on to state that no matter how stressful today's problems appear, it is essential not to forget the importance of logistics research and development.

Dr. Korb also summarized some of the "people problems"; he pointed out the continued decline in the 17- to 24-age group and touched on the difficulties in retaining highly skilled personnel. He also expressed his concern "... that the new technologies with the greatest potential to change support are not focused on support problems with much of a sense of urgency." Perhaps very high speed integrated circuit (VHSIC) technology could have "... a profound effect on readiness and sustainability if one or two orders of magnitude improvement in mission reliability for avionics were achieved."

Dr. Korb closed with a discussion of the MRA&L role in logistics R&D and how his group might help with recommendations to accelerate implementation of a logistics R&D program. Dr. Richard Webster, Deputy Assistant Secretary of Defense for Logistics and Material Management, and Dr. Russell Shorey, Director for Weapons Support, will be Dr. Korb's principal representatives. A recently completed analysis of industry IR&D activities found that about 2% of all IR&D man-years are directly allocated to support.

"Considering that about 25% of initial acquisition costs of weapons are logistically oriented, the [logistics R&D] field deserves greater attention." Dr. Dick DeLauer, Under Secretary of Defense, Research and Engineering (USDR&E), has supported this view by issuing a logistics IR&D policy statement tasking the Services to increase their efforts substantially in this vital area. MRA&L and USDR&E are exploring ways to encourage Service laboratories to become more involved in logistics R&D. One approach would establish logistics "centers of excellence" for areas such as diagnostics and repair.

### Service Presentations

#### Marine Corps Logistics R&D

Brigadier General William G. Carson, Jr., USMC, Director, Material Division, Installation and Logistics Department, summarized the Marine Corps responsibilities and some recent accomplishments in logistics R&D. The Marine Corps is responsible for the development of amphibious tactics, techniques, and equipment. Recognizing the transition to shipping by containers, the Marine Corps, in 1975, began a program of converting to standard containers for virtually all transport. Special-purpose standard containers have been developed for a variety of purposes, such as water purification, shelters of all sizes, medical laboratories and surgeries, bridges, and amphibious assault fuel systems.

The Marine Corps is in the process of converting from a motor transport tactical fleet of 54 types to one of only 7 types. The largest is the "Dragon Wagon," an 8 x 8 truck with a capacity of 22.5 tons, a 60-inch fording depth, and road speed capability of 55 mph.

#### Army Logistics R&D

Dr. Marvin E. Lasser, Director of Army Research, addressed the problem of the Soviets outpacing the U.S. by two to one in defense and graduating five times as many engineers. Dr. Lasser pointed out that 48% of U.S. Government spending is for social programs, 10% for debt service, 25% for defense, and only 17% for all else. Thus, defense expenditures in the U.S. cannot be markedly increased. The solution lies in this—our ever-expanding "information age." The younger generation is already growing up with the computer, and "intelligent" machines are easier to use. These developments have led to significant changes in the Army. In fact now all commanders will be given information to use with flexibility. Information is *not consumed*—it is not diminished by use.

Colonel John R. Tedesco, Material Readiness, DARCOM, reviewed the development of "Front End Readiness and Support Analysis Policies," MIL-STD-1388-1, Logistics Support Analysis (LSA), and the establishment of the LSA Steering Group in 1980.

Release of the revised MIL-STD-1388 is planned for late 1982. Colonel Tedesco briefly described the Standard Army Maintenance System (SAMS). He stated that life cycle cost (LCC) estimates for development and production costs are relatively good, but estimates of operational costs are poor. Colonel Tedesco described the pilot program use of microfiche Repair Parts and Special Tests Lists (RPSTL) in the Missile Command, with a final recommendation scheduled for February 1983. Potential application of videodisc technology for technical data storage and presentation and the briefcase-sized Personal Electronic Aid for Maintenance (PEAM) were mentioned.

Mr. Roland E. Berg, Assistant Director, Maintenance Management, Deputy Chief of Staff for Logistics, discussed the Army's growing commitment to logistics R&D and the fact that we need to think in terms of equipping the man rather than manning the equipment. He commented on the meaning of the Army policy of "support as far forward as possible." In practice, it is "support as far forward as practical."

#### **Navy Logistics**

Rear Admiral Alexander M. Sinclair, Assistant Deputy Chief of Naval Operations for Logistics, spoke of the emphasis in the Navy on readiness and sustainability and the fact that logistics is not glamorous. Admiral Sinclair noted the achievements of a 30% reduction in the complement of manpower for modern frigates compared with destroyers of 20 years ago and the four to one improvement in reliability and maintainability for the F/A-18 over the F-4. He is optimistic about the Navy being able to fully man a 600-ship fleet and is much encouraged by the fact that the Navy is attracting better personnel.

Commander J. Bland, Office of Naval Technology, described recent Navy accomplishments in logistics which were:

- Ship-to-shore power cables
- Field shower/laundry module
- Fuel storage tank water strippers
- Automated vehicle scheduling
- Handheld electric field detector for divers
- Improved fuel pumps
- Above the surf, elevated causeways for over-the-beach operations
- Navy automated publishing system (NAPS)

#### **Air Force Logistics R&D**

Major General Martin C. Fulcher, USAF, Assistant Deputy Chief of Staff for Logistics, spoke of the Air Force plans for logistics R&D. He emphasized the Air Force compliance with the "Carlucci Initiatives." General Fulcher noted that the Air Force is striving to operate in peacetime as closely as possible to wartime. In closing, he briefly described the soon-to-be-available "Air Force Logistics Research Studies Program 1982" publication which can be obtained from the Air Force Coordinating Office for Logistics Research, Wright-Patterson AFB, Ohio.

Colonel Robert Rankine, Commander, Wright Aeronautical Laboratories, described the four laboratories under his command: Aeropropulsion, Avionics, Flight Dynamics, and Materials. Some of the current efforts in these laboratories are:

- F-16 integrated fire and flight control
- Large composite structure materials
- Electromagnetic windows
- JP4 fuel from shale used in the F-16
- Engine technology

- On-board aircraft inert gas generator
- Cooperative sensor subsystem integration
- Integrated blade inspection system (IBIS)
- Super integrated power unit
- Advanced propulsion monitoring system (APMS)

#### **Perspectives from Industry - Panel**

The Industry Panel was organized and chaired by Mr. C. W. Collins, Vought Corporation.

Mr. W. M. Lyle, Manager, Advanced Logistics, McDonnell-Douglas Aircraft Company, stated that, in the programs on the F-15, F-16, and AV8B, most of the logistics R&D is accomplished through the program offices. Two of the current developments are the Avionics Fault Tree Analyzer (AFTA), a briefcase-sized unit which uses the aircraft as a "hot mockup" and the VSTOL tester for the AV8B, a suitcase-sized unit used off the aircraft. Mr. Lyle's strongest point was that repair times are measured in *hours*, but supply system delays are measured in *days*. Improvements *must* be made in the distribution systems.

Mr. Robert C. Gowans, Manager, Logistics and Product Support, Emerson Electric Company, described that organization with emphasis on the applied research done through the auspices of the Vice President for Engineering and Logistics. Current R&D projects at Emerson include a videodisc based interactive training system with a touch control panel.

Mr. Kenneth Lawrence, Engineering Manager, FMC Corporation, presented current R&D efforts at FMC pointing out that BIT for vehicles has not been developed to the extent that it has for avionics. He stated that the challenging areas of opportunity are training delivery systems, future technology, and front-end analysis.

Mr. John R. Griffin, III, Senior Systems Analyst, Dialectic Systems Corporation, made the point that major advances in science and technology are the result of a "paradigm shift"—a different way of looking at the problems. Such a shift occurred in logistics in about 1968 when the concept of *integrated* logistics developed.

Mr. T. Begley, Direct Product Support, Boeing Marine Systems, discussed current R&D efforts at Boeing Marine for various hydrofoil craft. He also gave some key points on improving the acceptability of IR&D projects in logistics to DOD technical monitors.

#### **Logistics Management Science Research and Development**

This session, organized and chaired by Mr. John Goclowski, Dynamics Research Corporation, addressed methods for developing the logistics component of the total design process. The intent was to give industry insight into techniques that the Services are using or considering in current and future acquisition programs.

Mr. James Baker, Army Research Institute, presented some of the current efforts at ARI. The thrust of his presentation was on matching the capabilities of the available personnel to future requirements for Army systems. The conceptual and design process for new systems must include an analysis of available personnel aptitudes and skills.

Mr. William Wallace, Reliability Engineering, Naval Electronics Systems Command, discussed level of repair analysis (LORA). He emphasized the need to begin LORA in the conceptual phase of new programs and the requirement for improved LORA modules with better users guides.

Colonel Donald Tetmeyer, Chief of the Logistics and Technical Training Division, AF Human Resources Laboratory (HRL), described some of his current programs. Among the programs discussed were:

- Integrated thermal/avionics design
- Anthropometric man in software
- Cybernetic logistics management
- Personal electronic aid for maintenance (PEAM)
- Better damage repair analysis
- Integrated training systems
- Remote systems maintenance for missile sites

In closing, Colonel Tetmeyer described the need for a maintenance support system which is rugged, portable, and updateable with distributed adaptive software which includes access to original design analysis information.

### **Application of Logistics R&D**

The intent of this session, organized and chaired by Mr. Gary L. Foreman, Hughes Aircraft Company, was to show what is happening in the applications world and where future activities should be directed.

Mr. Craig Hunter, DARCOM, discussed the preparation of a logistics support analysis record (LSAR) handbook which summarizes all available, currently used approaches to LSAR.

Lt Colonel Joseph Campbell, Headquarters USAF, discussed logistics capability assessment (LOGCAS) in the Air Force. He emphasized that the Air Force is currently using logistics computer models as tools for management and analysis. Among the models described were:

- Logistics capabilities measurement system (LCMS)
- Dyna-METRIC model
- Wartime assessment and requirement system (WARS)

Mr. M. Wiant, NACMAT, discussed the process and use of system availability calculations. Availability, calculated for planned systems and measured for fielded systems, is an accepted figure of merit.

Mr. G. T. Lussier, Headquarters U.S. Marine Corps, discussed why the preliminary calculated availability is frequently not achieved for fielded systems. In essence, the problem is one of definition.

### **Summary of Logistics R&D Directions**

Mr. Oscar Goldfarb, Deputy for Supply and Maintenance, stated that the same genius that produces performance can produce supportability; and the greatest marginal gains in supportability can be achieved through improvements in the prime systems rather than in the support systems. He further stated that logisticians can identify problems but the answers lie outside—we need to stop talking to ourselves.

Mr. Russell Shorey, Director, Weapons Support, Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics), stated that the commitment to logistics R&D throughout DOD is evident. Some of the needs are: deployable systems

with no support tail, paper free systems, and systems with zero processing delay. Finally, Mr. Shorey expressed his opinion that NSIA should organize and conduct a similar symposium next year.

Mr. Benjamin S. Blanchard, Assistant Dean for Engineering Extension, Virginia Polytechnic Institute and President of the Society of Logistics Engineers, summarized the symposium in the context of his position in academia. He related that logistics R&D in universities is minimal. The capability is there, but it is not being used.

As the last speaker in the symposium, I commended the previous speakers for their presentations which clearly showed where we are headed in logistics R&D. I need only look back a few years to see how far the Services, DOD, and industry have come in this area. The commitment to expand R&D for logistics is evident.

The new information handling and storage techniques, VHSIC, telecommunications, gallium arsenide devices, etc., are here. How are we going to both support and use these new technologies? We must now elevate support planning to the logistic mission analysis level. That is, the support system is a part of the "total system" that must be given consideration in the total mission analysis. We now have the policy and direction. We need the implementation of those policies via budgetary, IR&D, and contractual considerations. Nothing happens without plans and money.

I believe we are moving toward more effective use of technology and systems management techniques throughout all of the logistics disciplines. I believe that through R&D for logistics, effective solutions to the support requirements of the Services will be achieved.

### **Addendum**

#### **Logistics R&D in Westinghouse**

For more than a decade, the Westinghouse Electric Corporation, Integrated Logistics Support Divisions have been conducting R&D programs in logistics, both under contract to the DOD and as IR&D projects. The IR&D programs, performed at the Westinghouse Central Research Laboratories in Pittsburgh and the ILS Divisions in Hunt Valley and Columbia, Maryland, have addressed many aspects of logistics.

A brief listing of current projects includes:

- Computer based simulations of logistics processes
- An illustration comprehensibility index
- A data compaction method for illustrations
- Electro-optical detection and transmission of printed circuit board test signals
- Contactless detection of faults in integrated circuits
- Rule based artificial intelligence for test diagnostics
- Integrated test, training, and technical data systems
- Remote systems maintenance techniques
- Automated reading grade level analysis
- Automated editing system

### **Item of Interest**

#### **1983 Air Power Symposium**

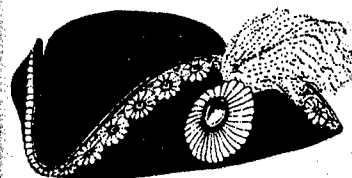
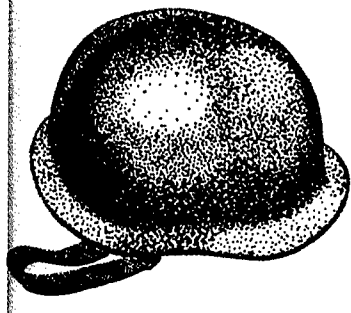
*Logistics will provide the subject matter for the 1983 USAF Air Power Symposium to be held in February. The title chosen is "Sustainability in Prolonged Conflict." The call for papers will be made soon by Air War College with submission due in the Fall.*

## Project Warrior

*Project Warrior is a concept formulated to create an environment where our people can learn from the warfighting lessons of the past and use that knowledge to better prepare for the future. Air Force Chief of Staff General Lew Allen, Jr., said: "I believe that a continuing study of military history, combat leadership, the principles of war, and particularly the application of airpower, is necessary for us to meet the challenge that lies ahead."*

## Logistics Warrior

*Logistics Warrior is the contribution of your journal to help create that environment. Your suggestions are solicited.*



### LOGISTICS WARRIORS: US in France, WWII

"Grand strategy didn't win the war. It was combat tactics that did it. The grand strategy was completely botched up after the first stages of the invasion, because of logistical failures.

General Patton was notorious for his lack of logistical knowledge, but major blame cannot be attached to him for the failure to carry out the CHASTITY [plan to seize South Brittany ports for more supply support]. He was under Bradley's orders. Middleton's corps, after being detached from the 3d Army, operated as directed by Bradley. It was Bradley's responsibility that the corps did not carry out the CHASTITY plan.

General Patton was a great combat general. He saved the Allies in the Battle of the Bulge by a magnificent display of military tactics. His great faults were his contempt for controlling orders from higher echelons and his refusal to pay sufficient attention to his logistical needs. . . .

To sum up, "Com Zone" could have done a much better job had it had a different organization. Lee, its commanding general, was not the man for the command. The whole supply setup from Supreme Headquarters down was badly organized. It could not have adequately supplied the combat forces without the facilities of the South Brittany ports and railroads.

Bradley failed to carry out his assigned mission to secure the South Brittany ports for several reasons. First, he overestimated the ability of the German forces in Brittany to be a real threat to our flanks and against our greatly superior forces. Second, he never really trusted Patton and his tactics. Third, he underestimated the logistical need for obtaining the use of Quiberon Bay and the railroads running east from there. These were most costly mistakes."

From: *The Critical Error of World War II* by Harold L. Mack.

### LOGISTICS WARRIORS: Materials/Friction

"Clausewitz's concept of friction describes why things naturally go wrong in war. . . . Friction is bad weather during the Battle of the Bulge, contagious panic in France in 1940, an empty prison at Son Tay, and the dominant characteristic of the Iranian rescue mission. A famous response to friction is the WWII phrase: "Keep it simple, stupid." Clausewitz considered friction to be the central factor that distinguished real war from theoretical analyses. The existence of friction means that war is not a deterministic process. The clarifying question concerning the impact of complexity on the man-machine relationship in combat is: *Does increasing complexity increase or reduce friction?*

By necessity, we need to look at real war so this question can only be answered through historical research. Col John

Boyd, USAF Ret., significantly enriches Clausewitz's concept of friction in his . . . "Patterns of Conflict." This briefing summarizes Boyd's research on conflict from 400BC to the present. According to Boyd, Clausewitz had a limited one-sided view of friction. Clausewitz was concerned about reducing his own friction (a valid concern) but he failed to see the *opportunities* for increasing his enemy's friction. Boyd observes that the writings of the Chinese military theorist, Sun Tzu, stress these opportunities and that the extraordinarily successful operations of Genghis Khan and Tamerlane exploited these opportunities. Boyd then synthesizes these two views with the operations of Genghis Khan, Napoleon, the successful German blitzkrieg commanders, and successful guerrilla commanders into a general theory of conflict—a theory that *he supports with historical analysis and observations from real war*. In sharp contrast to the deterministic view of the attrition mind-set, the central consideration in Boyd's theory is human behavior in conflict. In this context, he suggests that increasing complexity works on our mind and makes mental operations more difficult. It causes commanders and subordinates alike to be captured by their own internal dynamics—i.e., they must devote increasing mental and physical energy to maintain internal harmony—and hence they have less energy to shape, or adapt to, rapidly changing external conditions. In Boyd's perspective, the idea of *decreasing* complexity to diminish our friction and free up our operations gives us the *opportunity* to magnify our enemy's friction and impede his operations."

From: *Defense Facts of Life* by Franklin C. Spinney.

### LOGISTICS WARRIORS: Napoleon in Russia

"It should be recognized, however, that the worst shortages were experienced during the first two weeks of the advance (i.e. precisely the period for which Napoleon had made his most careful and extensive preparations) and that the situation gradually improved afterwards. Also, the *Grande Armée's* problems were at all times - including the retreat from Moscow - largely due to bad discipline. This, of course, was itself partly due to logistic shortages. However, the fact remains that those units whose commanders were strict disciplinarians (e.g. Davout's) consistently did better than the rest, while the Guard even managed to keep such good order that, far from running away, the inhabitants enthusiastically welcomed it. Nor is it true, as is so often maintained, that the country as a whole was too poor to support an army. Writing from Drissa early in July, Murat - operating as he was in an area which Pfuell had selected for the erection of his fortified camp precisely because it was supposed to be without resources - informed

Napoleon that while the region around was tolerably well provided it would be possible to exploit it only after a proper administration was set up and an end put to the troops' marauding.

"That the *Grande Armée* suffered enormous losses during its march to Moscow is true, as is the fact that hunger and its consequences - desertion and disease - played a large part in causing these losses. It would, however, be unwise to attribute this solely to the problems of supply. The need to protect enormously long lines of communication and to leave garrisons behind, and the effect of distance *per se* were also factors of major importance. As regards the army's material losses, there is reason to believe that much if not most of the equipment abandoned on the way to Moscow was later retrieved. In 1812 Napoleon's main force marched 600 miles, fought two major battles (at Smolensk and at Borodino) on the way, and still had a third of their number left when entering Moscow. In 1870, as in 1914, the Germans, operating over incomparably smaller distances, in very rich country and supported by a supply organization that became the model for all subsequent conquerors, reached Paris and the Marne respectively with only about half of their effectiveness. Compared with these performances, excellent as they were, the French Army of 1812, for all its supposedly worthless service of supply, did not do too badly."

From: *Supplying War* by Martin Van Creveld.

### **LOGISTICS WARRIORS: Firepower/Maneuver**

"In war, two great phenomena contend; maneuver and fire power. Maneuver is made of circumventing action to by-pass the barrier, to outflank the thrust, and to evade the main strength of the enemy in all instances from weapon design to grand strategy; such maneuver is the product of surprise, deception, and above all agility—in thought, planning, and action. And then there is firepower, which is measured by quantity, by accuracy, and by lethality; firepower is a product of industrial strength, transportation, and efficient logistic distribution. Throughout history, mixtures of maneuver and firepower have contended on a thousand battlefields. Maneuver has generally been the less costly course; but firepower has always been the surer course, and has demanded merely an outright superiority in means. But even in the face of superior firepower and superior resources, maneuver in all its forms—tactical, operational, theater-strategic and developmental, as well as the highest maneuver of grand strategy—has always done better than an outright comparison of forces would reveal and often has prevailed."

"But that was before maneuver finally met its match in the figure of the American 'systems analyst.' When this new apparition came to take its place alongside the Great Captains of history, maneuver was finally undone. Its fatal defect is that no statistical index can be properly attached to surprise, deception, or agility; thus no criterion of effectiveness stated in numbers can be defined for the system analyst's computations. Firepower by contrast is easily quantifiable: volume being tonnage, accuracy being hit probability, and lethality being a known factor."

From "On the Need to Reform American Strategy" by Edward N. Luttwak in *Planning US Security* edited by Philip S. Kronenberg

### **LOGISTICS WARRIORS: The Revolution**

"Under the stimulus of the war the public and private arms industry expanded production. In the winter of 1775-76 the arms makers of Pennsylvania, a center of the

industry, alone turned out more than 4,000 muskets. The production of artillery posed greater problems, but by 1775 the foundries in Philadelphia, Springfield, and other places were casting both bronze and iron guns that were almost as good as European pieces. Enough of these were made during the war to satisfy most of the requirements of the armies, and because of imports from France, American forces did not suffer serious shortages of guns. In another area of military procurement the Americans began and remained dependent upon foreign supplies. Relatively little gunpowder was manufactured in the colonies, largely due to a lack of saltpeter, and Congress and the states were unable to increase production. Over 90 percent of the gunpowder used in the war was imported.

The supply function of Congress did not cease when it created money to pay for the supplies or stimulated industries to produce them. They then had to be collected and distributed to the armies, and this would have to be done by a military staff. The Congress knew about the use of military staffs in European armies, and in 1775 it established its own. It authorized a number of offices, and appointed the holders of them, an adjutant general to handle records, a paymaster general to disburse money, and others. Two of these officials were concerned with supply and constituted what in later armies would be called the Services of Supply—a commissary general, who purchased and issued provisions, and a quartermaster general, who supervised the transportation of them to the armies. Later Congress appointed a clothier general, who received all clothing purchased by the Board of War. The various staff and supply officers were responsible to the Board of War, but the latter exercised only a loose coordination over them.

This failure to provide unitary direction reflected Congress's disinterest in efficient administration. The attitude was particularly apparent in its regulation of the supply services, and particularly calamitous. Thus at one time it became disturbed that the commissary general's department was not procuring needed provisions. The solution was to split the office into two parts, a commissary general of purchases and a commissary general of issues. The apparent reasoning was that if the job was too big for one man it should be given to two; the result, of course, was to divide authority still further.

The administrative indecision of Congress was one reason that shortages of certain supplies, particularly food, clothing, and shoes, appeared in the armies as early as 1776 and continued and grew worse every year thereafter.

"The suffering of the troops was not entirely due to administrative laxity. The goods in short supply were usually available in the country, but they could not be got to the armies. In part the problem was transportation. Just as the British had trouble in supplying their forces if they moved away from the rivers, so did the Americans. There were few good roads . . . and wagons were scarce. But the root cause of the problem was the Continental currency. As it depreciated steadily in value, producers tried to avoid taking it; many farmers preferred to sell to the British in return for specie. Congress was at last driven to recognizing the collapse of its currency system and the crisis of its supply system. Late in 1779 it authorized a requisition of "specific supplies" on the states. Quotas of various provisions, meat, flour, and other items, were assigned according to their resources. The states were expected to fill the quotas by assessing taxes in kind on their citizens. Barter was being substituted for currency."

From: *The History of American Wars* by T. Harry Williams.

**“Militarily, what can we do? We can reinforce. We can run away. We can move an analysis team to the scene. We can send technical assistance. Corporations can do the same thing. But the military must have an instant response.”**

General Harold K. Johnson, USA, ret., “Military Leadership and the Need for Historical Awareness”  
in *New Dimensions in Military History*, ed. by  
Russell F. Weigley.

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